DISCOVERED! Rings, long-lost spokes, and methane lakes at Saturn p. 52

June 2007

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The supernova next door

An exploding star could rock our galactic neighborhood p. 32

Eta Carinae, highlighted by crossed diffraction spikes, gleams above the Keyhole Nebula. One of our galaxy's most luminous stars, Eta Carinae will one day explode.

How William Herschel discovered Uranus p. 38

Explore forgotten treats in Scorpius p. 60

PLUS:

Stephen James O'Meara on Comet McNaught p. 20

The journey from film to digital astroimaging p. 68

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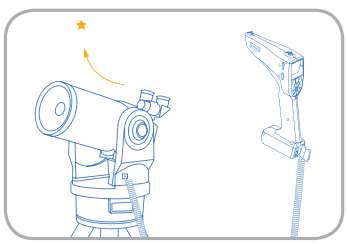

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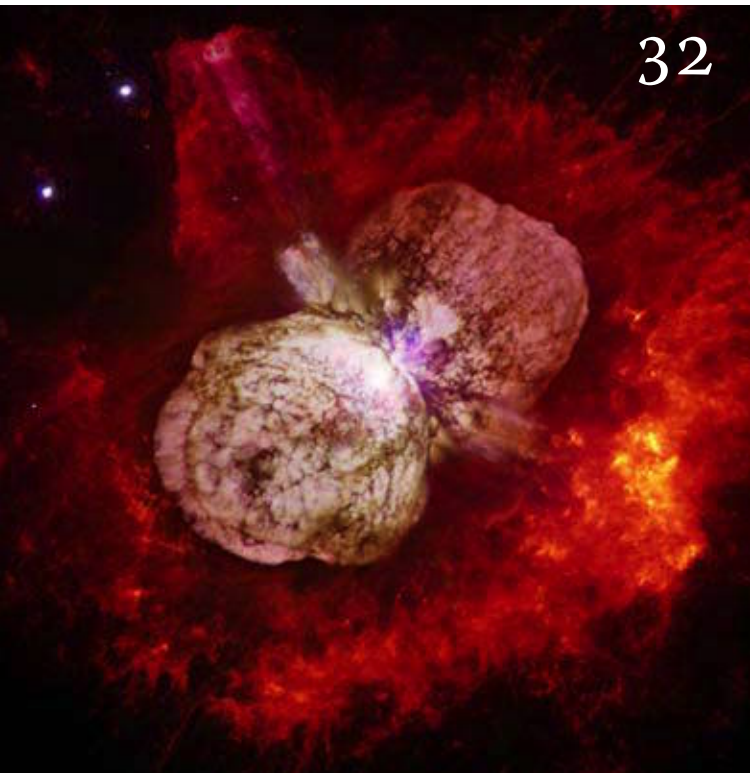

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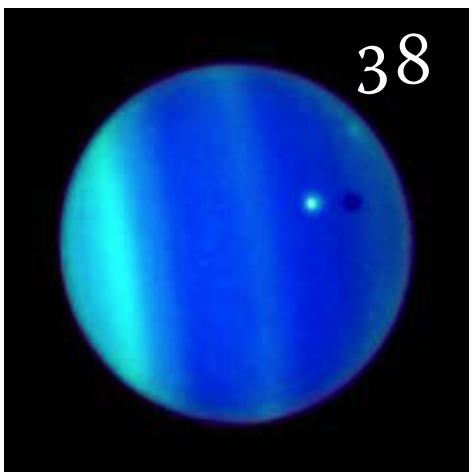

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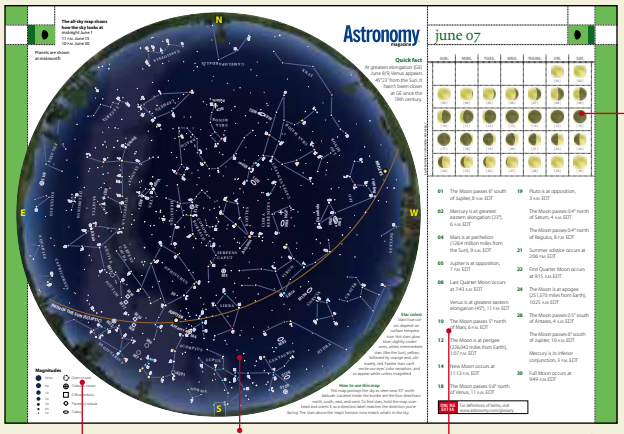

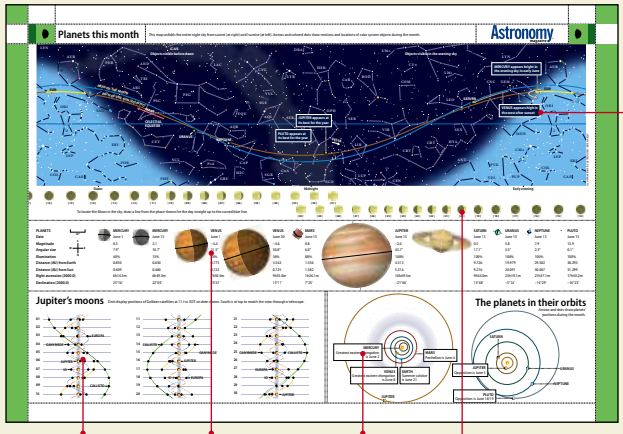

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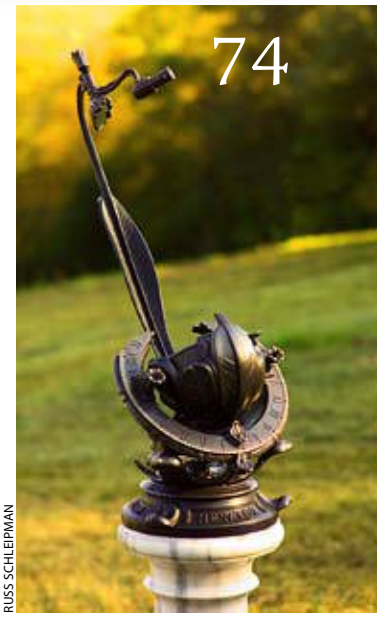

RUSS SCHLEIPMAN

BILL AND SALLY FLETCHER

ONLINE EXTRA Visit **Astronomy.com/toc** for bonus material — it's free and exclusive to *Astronomy* magazine readers. Follow the instructions on page 12 to get access.

BY DAVID J. EICHER

When will the next supernova blow?

We're a supernova-deprived society.

Yes, we had the spectacular, bright supernova 1987A in the Large Magellanic Cloud 20 years ago, but that was in one of our satellite galaxies. Observers and search networks have routinely spotted faint supernovae in galaxies like the Whirlpool (M51), M81 in Ursa Major, and a host of galaxies at the more remote distances of the Virgo Cluster and beyond. But I'm talking about a real killer — a phenomenally bright supernova in our own galaxy. The last Milky Way supernova exploded in 1604, and studies of other galaxies show that we're due for one in a galaxy the size of our own about every 50 years. So, which Milky Way star will go supernova next?

Speculations about supernova candidates have focused on elderly red giants like Betelgeuse in Orion. But there's another, even more intriguing possibility: As Associate Editor Frank Reddy writes in "The supernova next door" (page 32), "Eta Carinae is among the most massive, luminous, and violent stars known." Astronomers know that Eta Carinae will one day explode spectacularly as a supernova. New clues from Eta Carinae suggest, however, that the eventual supernova status of this giant star may be closer than anyone had expected.

In his story, Reddy explains the long and convoluted observational history of Eta Carinae. The star has frequently been characterized by weird, erratic brightness swings. After showing several decades of unpredictability, for example, in 1842, Eta Carinae briefly brightened so explosively that it "outshone every star except Sirius," Reddy writes.

Much later, astronomers classified Eta Carinae as a Luminous Blue Variable, a rare type of massive star that can erupt violently for short periods, rivaling supernovae in brightness. Hubble Space Telescope observations show the short-period variability of the star reflected in the nebula's changing shape, size, and brightness.

Following the star's "great eruption" in the 1840s, Eta Carinae mysteriously dropped off sharply in brightness. Over the past 8 decades, however, the mystery star has been on the rise again, signaling possible eruptions. Reddy's article describes all the latest science on one of the most fascinating and important objects in our neighborhood of the galaxy.

Aside from erratic stars, I want to alert you to a feature we've added to our web site: videos shot in our Kalmbach studio, produced by the *Astronomy* staff with the help of Kalmbach's talented video production team, led by Keith Bauer and Laura Baird. At press time, the first several videos include a Celestron telescope review by Michael Bakich, a Meade telescope review by Laura Layton, an "Astronomy Update" by Daniel Pendick, and a segment on sketching objects at the eyepiece by yours truly. I hope that you'll enjoy these online videos — unique to our hobby — and the many more to come down the road.

Sincerely,

David J. Eicher
Editor

Astronomy

Volume 35, Number 6

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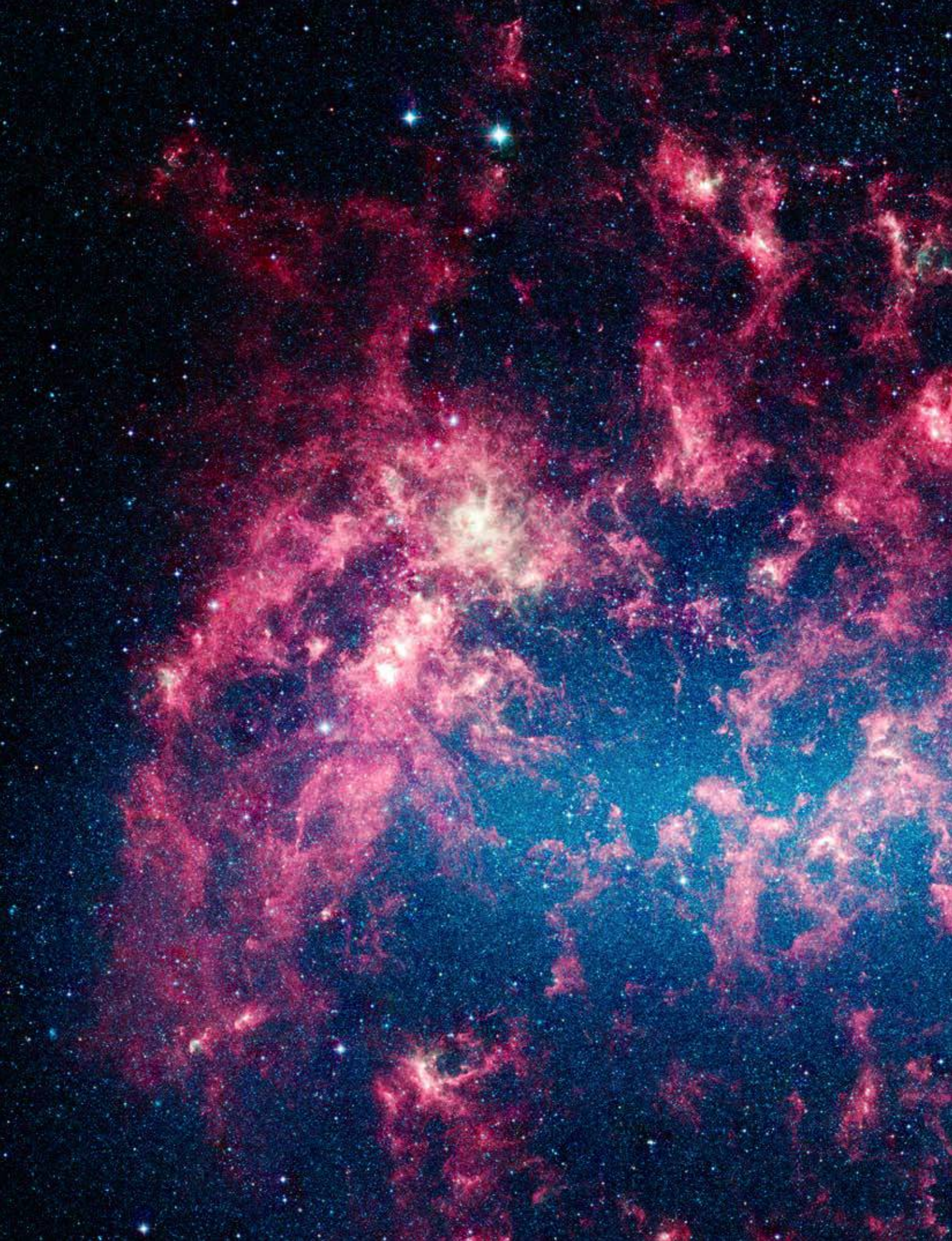

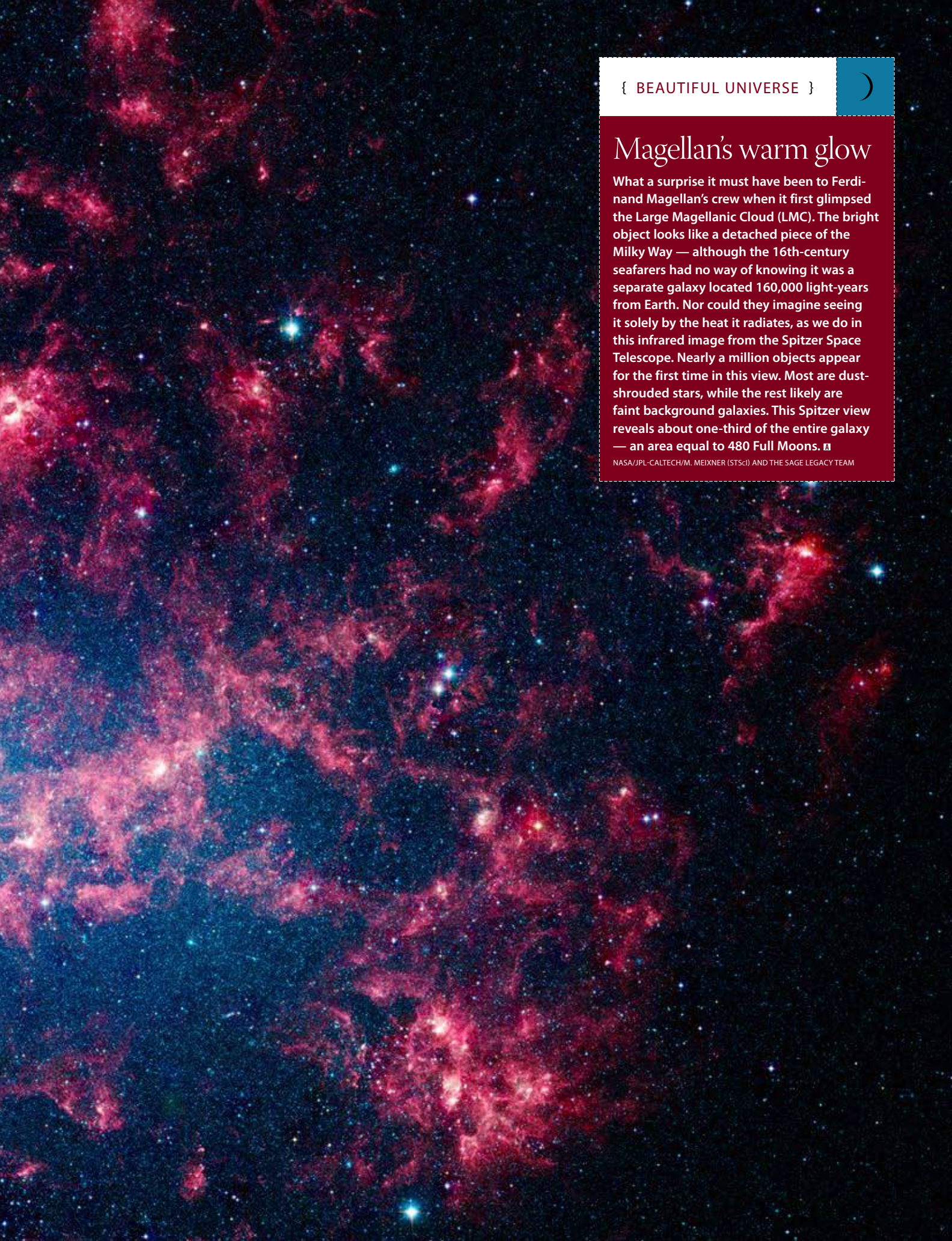

Magellan's warm glow

What a surprise it must have been to Ferdinand Magellan's crew when it first glimpsed the Large Magellanic Cloud (LMC). The bright object looks like a detached piece of the Milky Way — although the 16th-century seafarers had no way of knowing it was a separate galaxy located 160,000 light-years from Earth. Nor could they imagine seeing it solely by the heat it radiates, as we do in this infrared image from the Spitzer Space Telescope. Nearly a million objects appear for the first time in this view. Most are dust-shrouded stars, while the rest likely are faint background galaxies. This Spitzer view reveals about one-third of the entire galaxy — an area equal to 480 Full Moons.

NASA/JPL-CALTECH/M. MEIXNER (STScI) AND THE SAGE LEGACY TEAM

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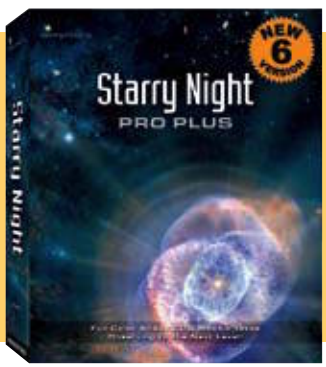

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Astronomy's Summer 2007 Sweepstakes Official Rules

1. No Purchase Necessary. Official entry forms are bound in the June 2007, July 2007, and August 2007 issues of Astronomy. The *Astronomy* 2007 Summer Sweepstakes is open to residents of the United States and Canada (except Quebec) only, 18 years of age or older. Employees (and their dependents and immediate household members) of Kalmbach Publishing Co., their advertising and promotional agencies and sponsoring companies are not eligible to participate.

2. Sweepstakes Entry. To enter, complete and mail the official entry form or a postcard with name, address, city, state or province, and zip or postal code to: The Astronomy 2007 Summer Sweepstakes, P.O. Box 1199, Waukesha, WI 53187-1199. Or enter online by filling in the Online Entry Form and hitting the SUBMIT ENTRY key. The Online Entry Form must be filled out completely to be eligible. Incomplete or defaced entry forms are void. One entry per household. The official ending date for The Astronomy 2007 Summer Sweepstakes will be August 20, 2007, and all entries must be transmitted or postmarked no later than that date.

3. Prizes and Odds of Winning. One drawing will be held on or around October 19, 2007 for the following awards: One (1) Grand Prize consisting of a Sirius 120ED EQ-G GoTo Apo Refractor (retail value $3,099.95). One (1) First Prize consisting of a SkyQuest XT8 IntelliScope with Computerized Object Locator (retail value $619.95). One (1) Second Prize consisting of a *Starry Night Pro Plus 6.0* (retail value $249.95). One (1) Third Prize consisting of a StarShoot Solar System Color Imager II (retail value $179.95). Ten (10) Fourth Prizes each consisting of a one-year subscription to *Astronomy* magazine (retail value $42.95 each). Fifteen (15) Fifth Prizes each consisting of a copy of *Astronomy* magazine's special issue, Atlas of the Stars (retail value $12.95 each). Cash equivalents of merchandise will not be awarded. Substituting prizes is not allowed. Any applicable federal, state, and/or local taxes are the responsibility of the winner. Odds of winning depend on the number of entries received. Total circulation for Astronomy is 131,288. Sweepstakes void in Quebec and void where prohibited.

4. Validation and Acceptance. Winners in the *Astronomy* 2007 Summer Sweepstakes will be selected in a random drawing. Canadian prize awards subject to skill test requirement. By entering the sweepstakes, participants agree to be bound by these official rules and all decisions of Kalmbach Publishing Company. Sweepstakes entries void if not legible, not completed in full, not obtained legitimately, or if forged, photocopied, mechanically reproduced, late or tampered with. The potential winners may have to sign and return an Affidavit of Eligibility, publicity release and Release of Liability within fourteen (14) days of notification. In the event of non-compliance, alternate winners will be randomly drawn. No responsibility is assumed for lost, stolen, misdirected or late entries or notifications. All sweepstakes entries become the property of Kalmbach Publishing and will not be returned.

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Remember winter?

In "Explore winter's 12 best

star clusters" (February 2007), Steve Coe writes, "Although the air may be cold, you'll hardly notice the weather when you gaze at these stellar treats." I know it's probably warm during winter in Arizona, despite the fact that it received snowfall for the first time in a century this past year.

I live about 30 miles (50 kilometers) north of Toronto, Ontario, where the temperature outside is 0° F (–18° C) in January. Considering that it's colder at night (plus, any wind makes it feel even colder), I invite Coe to see how much he notices the weather here.

If he would rather be under a dark sky, he could always drive a little farther north, to my preferred viewing site, or contact someone in Fairbanks, Alaska. Just make sure he brings an electric snowmobile suit with him. **— MARC RIENDEAU,** AURORA, ONTARIO

Check Pluto's stats

As I continue to read about Pluto's demotion, I wonder why this is a big issue. To me, it's an issue of statistics: The sample size to determine what a planet is isn't big enough to matter.

Pluto's still there, as are many other untold mysteries waiting for us. That's where we should keep our focus. **— CHRIS MALACHINO,** GRAND RAPIDS, MICHIGAN

STANDOUT STAR CLUSTER **M50 is a naked-eye object in a dark winter sky. Despite the temperatures, winter provides great observing.** NOAO

Excellent issue

I have been a subscriber and amateur astronomer for almost 2 years. I always read your magazine cover-to-cover, but I had to write you about the March 2007 issue and let you know what a wonderful job you did. Every page contained something to further my understanding of astronomy. **— ELMAR "ROZIE" ROZENBERG,** SHOREWOOD, MINNESOTA

We welcome your comments. Send letters to Astronomy *Letters, P. O. Box 1612, Waukesha, WI 53187; e-mail to letters@astronomy.com. Please include your name, city, state, and country. Letters may be edited for space and clarity.*

When did Cas A actually explode?

Your "Beautiful universe" photo spread in February 2007 said the explosion that created supernova remnant Cassiopeia A occurred in 1667, and that it was detected by a radio telescope in 1947. But the text says the site of the explosion was 10,000 light-years away. How can that be? **— DONALD A. SAWYER,** CEDAR KEY, FLORIDA

NASA/ESA/THE HUBBLE HERITAGE TEAM (STScI/AURA)

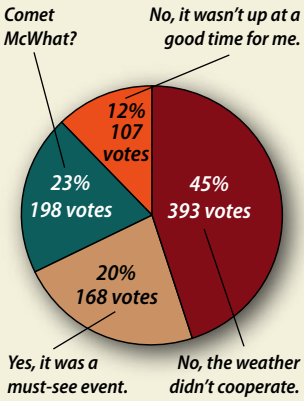
CASSIOPEIA A'S star blew up 10,000 years ago.

It took 10,000 years for the light to reach Earth because the exploding star was 10,000 light-years away. To minimize confusion, astronomers routinely refer to events as they are seen from Earth.

So, in the case of Cas A, when we said an explosion rocked a star in Cassiopeia in 1667, we meant it as the day the explosion would have been seen from Earth. If not for the thick dust clouds that blocked the view, observers would have seen the supernova then. What we saw in 1947, and see now, is radiation from the expanding supernova remnant. **— RICHARD TALCOTT, SENIOR EDITOR**

Online poll results

POLL QUESTION:
Did you observe Comet McNaught in January?


Comet McWhat?
No, it wasn't up at a good time for me.
12% 107 votes
23% 198 votes
45% 393 votes
20% 168 votes
Yes, it was a must-see event.
No, the weather didn't cooperate.

Total votes: 866

Join the fun! Each week, Astronomy.com posts a poll question for visitors to answer. You can find the question on the lower right side of the home page.

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BY BOB BERMAN

Don't look at me like that

Do you look into people's eyes when you talk to them? Our culture neither requires nor condemns this etiquette. Some folks squirm if you gaze into their pupils. For others, failure to "look them in the eye" means you're hiding something. When watching celestial bodies rather than human ones, the dilemma remains. Sometimes, it's best to stare directly. Other times, you get better results through averted vision — looking off to the side.

The strategy is due to the retina's design. Images are focused through our pupils onto the fovea, the center spot, where the light meets 8 million cone-shaped cells crammed into a small area. This zone of so-called photopic vision works only in bright light.

Digression: The location of what we see is commonly taken to lie "out there" in front of us. But everything we see, the images themselves, actually occur in the occipital lobes of our brains. In a very real sense, there is no external world. You perceive only the inside of your brain, where everything visual actually takes place.

Too far out? Let's continue with the second variety of vision, which kicks in when light dims. Away from the fovea lie 20 million rod-shaped cells, whose sin is color-blindness. Not one rod lurks in the middle 1° of vision; they're most densely packed 15° to 20° from dead center. So, in low-light situations, when cones no longer operate, we suffer a 1° blind spot at the center of vision.

There's also a second blind spot caused by the optic nerve. This one's not centrally located, and we don't usually notice it: If an object is hidden at the blind spot of one eye, it will be seen by the other.

Anyway, to most clearly observe using rods, you need to look about 15° away from the object of interest, while nonetheless keeping your attention on it.

Another quirk of rods is total blindness to red objects. You can demonstrate this with a Christmas tree bulb on a dimmer. Using any color except red, slowly turn the brightness down. Eventually, you'll reach a point where color vanishes, but light is still perceived as gray. This is the luminosity level at which cones no longer function, and rods take over. Now try it with a red bulb. The results are different: Now light completely disappears the same moment its color vanishes. We simply cannot perceive faint red light at all, even as gray. And if the dim object is smaller than one angular degree, it will vanish if we stare at it directly, no matter its original color.

> YOU PERCEIVE ONLY the inside of your brain, where everything actually takes place.

Rods are also very slow-reacting, which is why it takes so long to acquire night sensitivity. Scotopic vision switches on whenever ambient light falls below 0.3 lamberts, which, alas, is precisely the realm vampires and astronomers most adore. More than 99 percent of the things we observe telescopically shine at these low light levels. And after enduring these deficiencies, scotopic vision still delivers only 20/200 acuity, 10 times less sharp than photopic vision. You've always sensed the truth of this. Haven't you noticed that details on galaxies are smudgy, while the Moon can be wonderfully sharp? That's where astrophotography comes to the rescue — by revealing the fine features and colors of faint objects that our rods simply can't perceive, ever.

So, the real fun starts when we learn how best to put scotopic averted vision to work. These nights, Cancer is still in the west at nightfall. Its famous Beehive Cluster (M44) was noted through history as a blob, a nebula. Yet people with normal eyesight can gloriously split it into individual stars with just their naked eyes — but only by using averted vision. Wham! The blur breaks into distinct star points.

At that same hour, Lyra rises in the east. Look at Epsilon (ε) Lyrae, the nearest star to Vega. Try it with direct, then averted, vision. Here, direct vision works best because Epsilon is bright enough to stimulate some cones, allowing good sharpness resolution. If you're blessed with 20/15 vision, Epsilon splits into two components that provide the best eyesight test in all the heavens.

Use averted vision under dark skies to increase the naked-eye Pleiades or to telescopically glimpse spiral arms on NGC 4565's dust lane, but not to discern fine planetary detail such as Saturn's Cassini Division. This tool requires some practice and care.

Who would have guessed that in dim light, the clearest scenes materialize only when we don't look at them?

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Those authors smoothed the way for H. G. Wells, whose highly imaginative works were suffused with social criticism, while Franz Kafka's bizarre tales criticized society's institutions. Fantasy by mid-20th century had few restraints. J. R. R. Tolkien created entire worlds of fantasy, with their own geographies and languages. Children's literature became especially fertile ground for fantasy.

Science fiction is, says Professor Rabkin, the most important fantasy genre today. After a look at Frankenstein, he examines the works of Jules Verne, Ray Bradbury, Robert A. Heinlein, Isaac Asimov, and Arthur C. Clarke, all of whom use the future, technology, and science in imaginings that illustrate some of humanity's most probing questions.

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Offer Good Through: June 29, 2007

BY GLENN CHAPLE

Full Moon fever

Most observers hate the Full Moon.

Bright and brash, it floods the night sky with nature's version of light pollution. Even the Moon is a washout. With sunlight striking the lunar surface head-on from our viewpoint, there are no shadows to highlight craters or mountains.

However, some lunar features — like relatively young craters and their ray systems — are best seen when the Moon is at or near full phase. To explore the Full Moon telescopically without ravaging your retina, you'll need to reduce the glare. For under $20, you can buy a neutral density filter (25-percent light transmission for small scopes; 13 to 18 percent for larger instruments). A variable polarizing filter is more versatile; which lets you adjust the amount of light entering the eyepiece. Expect to pay upwards of $50.

In my November 2005 column, I described inexpensive planetary filters that you can make from GamProducts, Inc., theatrical filters. For making lunar filters, I found their CineFilter .6 (item number 1516) and .9 (1517) neutral-density filters work nicely with the Moon. Generous 3½" by 4" samples — large enough to make four filters of each — are included in GamProducts' CineFilter sampler swatch book.

Wabash Valley Astronomical Society member Marilyn Sameh mounts homemade filters on lids from the plastic jugs that hold dairy products. She writes: "Take a washed lid, and whittle some threads on the inside with an X-ACTO knife. Resting the lid upside down on a small pill bottle, cut about a ¾" hole in the lid. Holding the lid in hand, expand the hole, making it a little less than 1⅛" across.

"To attach the filter material to the lid, use a ⅛"-thick sheet of foam and some plasticized cardboard material. Make the ring the size of the lid's top — not quite 1½" in diameter with a hole about 1$\frac{1}{16}$". Place tacky white glue on one side of the ring, then place it down on a circular 1½" piece of the filter material. After it dries, trim the edges and glue it to the lid.

"Make sure to determine if the lid will fit over your eyepieces, either with the eyeguard up or turned down, beforehand."

Questions, comments, or suggestions? E-mail me at gchaple@hotmail.com

Glenn's fab 5 lunar telescope targets

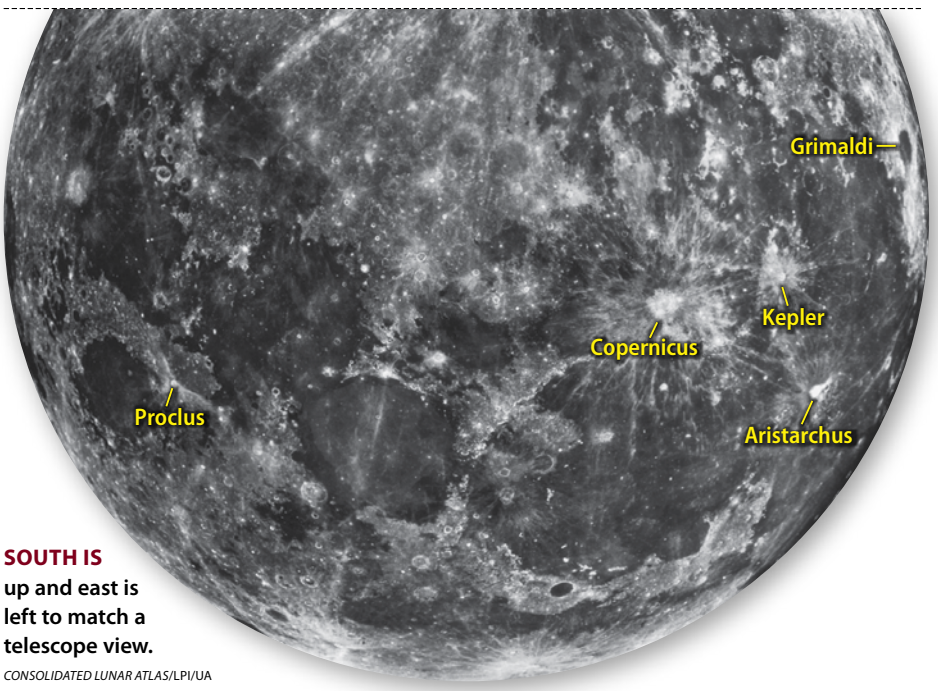
Telescope and filter ready? Using this guide, locate these features, using low power, then switch to higher magnification for a close-up view.

1&2 COPERNICUS AND KEPLER: Two other legendary astronomical figures are represented by bright, rayed lunar craters. Copernicus and Kepler stand out against the dark surroundings of Oceanus Procellarum (Ocean of Storms).

3 ARISTARCHUS: Easily identified with the naked eye, this crater is the brightest feature on the Moon's nearside.

4 PROCLUS: Second in brilliance only to Aristarchus, this crater lights up the western edge of Mare Crisium (Sea of Crises). Proclus' unusual fan-shaped ray system indicates an oblique strike by the impacting body.

5 GRIMALDI: Bright areas aren't the Full Moon's prime real estate. Look for the darkest Full Moon feature of the walled plane Grimaldi, situated close to the western limb. —*G.C.*



SOUTH IS up and east is left to match a telescope view.

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BY PHIL HARRINGTON

Tour Apollo's sites through binoculars

"Once in a Blue Moon." We use this phrase when talking about something that happens on rare occasions. Today, astronomically speaking, the Blue Moon refers to the second Full Moon occurring in the same calendar month. Since there are about 29.5 days between Full Moons, every now and then the phases will line up so that the full phase will occur on the 1st or 2nd of a month and a second full phase will take place on the 30th or 31st.

Using Universal Time as our measure, June boasts a Blue Moon. The first Full Moon this month occurs at 1:04 A.M. June 1, while the second happens at 1:49 P.M. June 30. The popular media likely will attribute a Blue Moon to May, because the June 1 Full Moon will actually occur at 9:04 P.M. EDT May 31, making it the second that month.

Let's celebrate the Blue Moon with a tour of our neighbor through binoculars.

Because next month marks Apollo 11's 38th anniversary, let's explore the regions where each mission touched down.

Apollo 11: The dark gray outline of Mare Tranquilitatis (Sea of Tranquility) looks almost perfectly round from our vantage point. The best time to view Mare Tranquilitatis is during the waxing crescent phases, the week of June 17.

Apollo 12: The mission's landing site lies south of the prominent crater Copernicus, which sees sunrise 2 nights after First Quarter. Watch as sunlight first bathes the crater's sharply defined walls, catching the strong central mountain peak, before sliding down to the crater floor. Mark your calendar to come back in a few nights when Copernicus' brilliant ray system explodes against the mare's darker background. The starburst pattern is unmistakable through even the most modest binoculars.

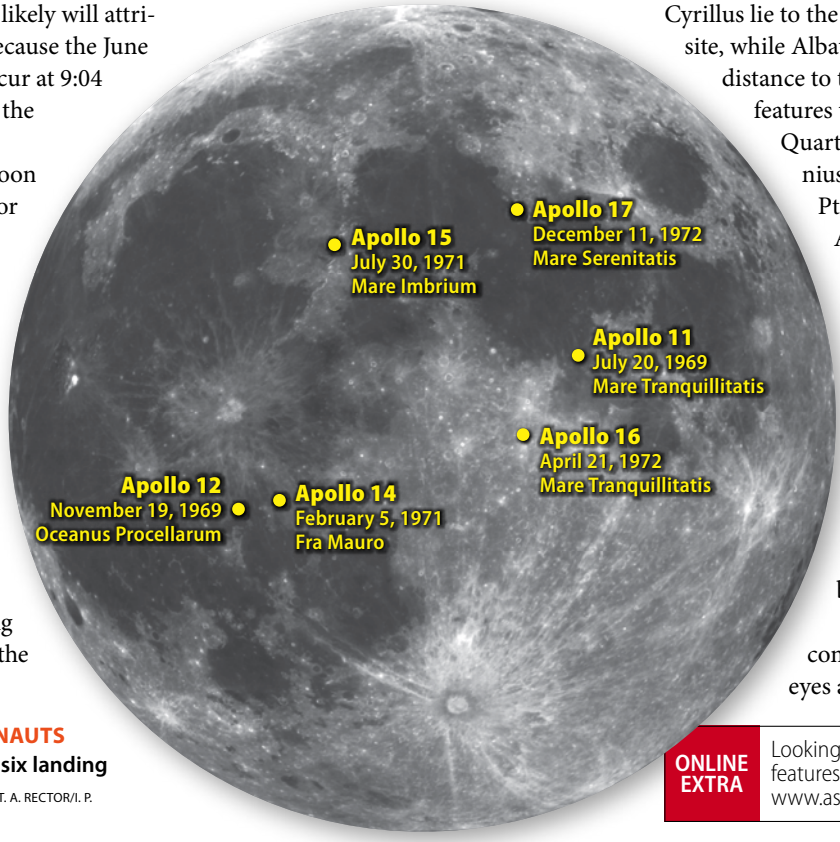
Apollo 14: This mission touched down at the hilly region Fra Mauro, near the southeastern shore of the Ocean of Storms.

Apollo 15: The Apennine Mountains, mark the southeastern edge of Mare Imbrium (Sea of Rains). The Apennines' arc is found just south of a triangle of craters: Aristillus, Autolycus, and Archimedes. All three will lie near the Moon's terminator the night after First Quarter.

Apollo 16: The craters Theophilus and Cyrillus lie to the east (right) of the landing site, while Albategnius is about an equal distance to the west (left). View these features the night before First Quarter. Just west of Albategnius, three more craters — Ptolemaeus, Alphonsus, and Arzachel — see sunrise the following evening.

Apollo 17: The final Apollo site rests near the Taurus Mountains, forming the eastern rim of Mare Serenitatis (Sea of Serenity). The best time to view the range is during the waxing crescent phases, between June 18 and 21.

Remember, when it comes to Moon-gazing, two eyes are better than one!



TWELVE APOLLO ASTRONAUTS left their footprints across six landing sites on the lunar surface. T. A. RECTOR/I. P. DELL'ANTONIO/NOAO/AURA/NSF

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IMAGINOVA

BY STEPHEN JAMES O'MEARA

The zodiacal light and Comet McNaught

When Comet C/2006 P1 (McNaught)

burst onto the celestial scene last January, it thrilled us with one spectacle after another. This versatile visitor transformed itself from a binocular beauty to a graceful daylight dancer to a glorious southern belle. But as often happens when we become mesmerized with a star attraction, it's easy to overlook others nearby.

A great comet tail

On January 16, after McNaught dipped below the Northern Hemisphere's horizon, keen-eyed Paul Robinson near Boulder, Colorado, noticed the northern tip of the comet's highly-striated tail rising above the western horizon "like faint auroral rays." Once alerted to the news, observers across the Northern Hemisphere dashed outside to observe yet another rare comet display.

On the evening of January 18, I noticed the base of the zodiacal light looked abnormally bright in the western sky. Unaware of Robinson's observation, I quickly sketched the light's appearance, and then turned my attention to other things. Imagine my surprise the next morning, when I visited Spaceweather.com. Colorado amateur Daniel Laszlo had photographed the comet and the zodiacal light. I wondered if the two phenomena were related.

The zodiacal light is a large cone of soft light that appears in the eastern sky just before dawn or in the western sky shortly after dusk. If you could join these two cones at the base, they would form a single lens of light centered on the Sun, with a major axis nearly coincident with the ecliptic's plane, or zodiac — thus the phenomenon's name.

The glow is caused by sunlight scattering off dust particles lying in this ecliptic plane. Observations by the Diffuse Infrared Background Experiment aboard the Cosmic Background Explorer satellite have shown that 89 percent of the dust responsible for the zodiacal glow between Earth and the Sun is from comet dust tails. (The Greek philosopher Aristotle, then, was right in his thinking that the phenomenon was a comet whose head was not visible.) Because Comet McNaught sailed within 16 million miles (26 million kilometers) of the Sun, I wondered if dust shed from the comet's tail had not contributed to the brightening I perceived in the zodiacal light the evening of January 18.

COMET McNAUGHT'S TAIL TIP was visible for Northern Hemisphere observers in January, despite the main body sinking below the horizon. JIMMY WESTLAKE

A zodiacal mystery

The problem with making claims about intensity changes in the zodiacal light is that the glow is so feeble, its appearance can be greatly altered by atmospheric conditions or the state of the dark-adapted eye. Indeed, as early as May 1898, British observer William Anderson noted in the *Monthly Notices of the Royal Astronomical Society* that "The variation in appearance of the light from night to night is largely, if not entirely, due to atmospheric causes."

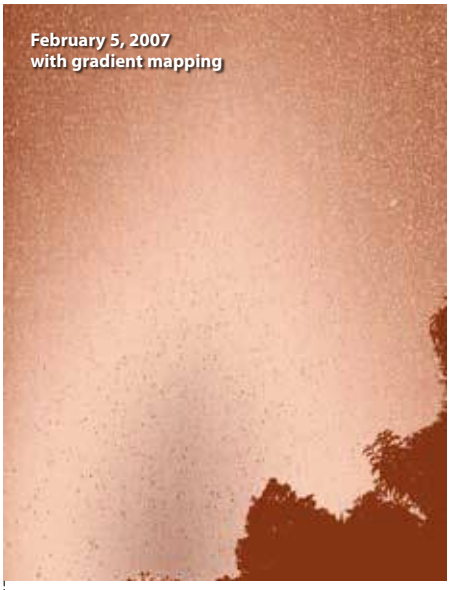
Data from NASA's OSO-5 satellite support Anderson's comment. From January 1969 to January 1973, a zodiacal-light study failed to show any temporal variations in its surface brightness and polarization. Any variations that do exist would be less than 10

COMET McNAUGHT and the zodiacal light brightened the horizon in this image.

ALL PHOTOS BY STEPHEN JAMES O'MEARA

THE COMET disappeared from the sky, but the zodiacal light returned to normal, perhaps slightly more intense than usual.

THE COMET'S SYNCHRONES are easily identified in this image after the author altered the gradient mapping.



WITHOUT COMET McNAUGHT, this gradient-mapped view of the zodiacal light appears intense above the horizon.

percent of the light's mean intensity. Still, such studies are themselves temporal — the appearance of great comets with dusty tails can occur on the order of decades, not years. So might there be exceptions?

Because the zodiacal light is relatively faint, observations of it demand the absence of moonlight and any artificial light, which can reduce the contrast between it and the background sky. I say "relatively," because under a dark sky, the zodiacal light can be more intense than the Milky Way. And because the glow follows the ecliptic, its orientation varies with latitude and from season to season. This variation affects its visibility, especially from temperate latitudes, where the glow can be dimmed by extinction and horizon hazes.

From tropical locations, the zodiacal light is a nightly wonder. Under pristine conditions, it can extend from the horizon — where it is widest — to the zenith. A careful scan of the light cone will reveal a bright central region, which spans roughly 10° at the base and about 30° along the major axis. A faint outer envelope can extend the cone to 30° by 90°, respectively. On especially clear nights, a narrow corridor of light, called the zodiacal band, appears to slice through the entire cone, from top to bottom, splitting it in two. This pristine view of the zodiacal light is what I saw January 18, except that the cone's base was awash in an abnormally bright white light.

Inspired by Laszlo's photograph, I drove to the 7,000 foot-level (2,100m) of Hawaii's Mauna Loa volcano January 19 and imaged the zodiacal light and the superimposed synchrones — dust from the comet's nucleus. The synchrones, about a magnitude brighter than the zodiacal light at its base, appeared as a half-dozen or more phantom brush strokes against a rich canvas of smoking starlight. The bands remained visible for the next 3 nights. They expanded in length and faded from view as a waxing crescent Moon smothered them with its own feeble light.

When the Moon departed the sky 2 weeks later, I returned to the site to image the zodiacal light without the synchrones, making sure to duplicate the same observing conditions and the same exposures as those of January 19. Visually, the zodiacal light seemed intense, but normal — perhaps just a tad brighter than usual. Most noticeable, however, was the greatly diminished brightening of its base.

One could argue that the zodiacal brightening was achieved by a simple coincidental pairing of the bright synchrones against a normal zodiacal light. However, synchrones are simply dust in a comet's tail. And what is the inner zodiacal light but mainly dust from comet tails? Whatever you decide to believe, the photographs make apparent that, at least for a few days, the zodiacal light had not only a temporal brightening caused by the superposition of dust from a comet's tail, but also some fine, striated structures.

By the way, the last time I recorded that the zodiacal light was abnormally distinct was in spring 1997, when Comet C/1995 O1 (Hale-Bopp) passed through it.

I'm interested in any reports you have relating to comets and temporal changes in zodiacal light. Send your observations to me at someara@interpac.net.

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Two new smaller TMB triplet apo refractors join the *2007 Hot Product* TMB-130 triplet!

The 130mm f/7 **TMB Optical TMB-130** apochromatic triplet refractor is a *Sky & Telescope 2007 Hot Product.* Unlike other premium refractors with multiyear waiting lists, this outstanding $3999 apochromatic refractor from renowned optics designer Thomas M. Back is available now.

The new 92mm f/5.5 **TMB-92**, a compact (under 13" long!) triplet apo fills the void left by the discontinued Astro-Physics Stowaway (a legendary scope that sells for up to $6000 on the used market). But you won't pay $6000 for the TMB-92. This new compact TMB apo refractor is only $1999.

The TMB-130 and TMB-92 have collimatable lens cells and each features a famous *FeatherTouch* dual-speed rotating rack and pinion focuser (with a 3.5" drawtube on the TMB-130, and a 2.7" on the TMB-92).

Also new is the **TMB-80**, an 80mm f/6.3 triplet apo for only $995. It's the first time a TMB-quality scope has been available at such an attractive price. Like all TMBs, it uses premium FPL-53 ED glass in its fully multicoated apochromatic triplet lens. The TMB-80 has a rotating 2" Crayford focuser, 1.25" and 2" compression ring eyepiece holders, and more. A TMB apo for under $1000? Wow!

New lower Meade ETX prices save you $50 to $195.

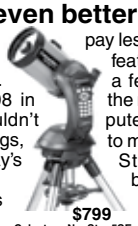
The best-selling **Meade ETX-90PE** 3.5" Premier Series go-to Maksutov-Cassegrain telescope with UHTC multicoatings, left, now costs you only $699. You save $50.

And the new lower $999 price of the 5" **Meade ETX-125PE** saves you $195.

It doesn't take a rocket scientist to use an ETX. All you have to do is tell it your zip code. *Level North Technology* automatically moves to two alignment stars. Center the red dot finder on those stars. Then tell your ETX which of the 30,000+ objects in its memory you want to see, and the scope takes you there *automatically.*

Each Meade ETX comes with adjustable height tripod, red dot finder, 26mm Super Plössl eyepiece, and you can choose from a classic blue tube or one with a full-color deep space image.

In 1979, a coffee cost 25¢ and a Celestron 8 cost $1295. Today, $1399 buys an even better *go-to* Celestron 8.



As for coffee, you practically have to mortgage your house to buy a cup at Starbucks these days.

A 1979 C8 would cost $3667.08 in today's inflated dollars – but wouldn't have the go-to computer, multicoatings, DC drive, or Plössl eyepiece of today's $1399 **Celestron NexStar 8 SE.**

But it *would* still have Celestron's excellent Schmidt-Cassegrain optics. That's one important benefit that hasn't changed over the years.

A Celestron's cost has actually *deflated* over the years. You get more scope, but pay less money, because many of today's features were unavailable at *any* price a few short years ago. Features like the no-guesswork *SkyAlign* go-to computer that finds objects automatically to make astronomy easy as 1-2-3, and Starbright XLT multicoatings for brighter images and higher contrast.

The **Celestron NexStar SE** telescopes. Great values? *Yes!*

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Equipment reviews? *www.cloudynights.com*

New super Celestron values for the first-time buyer.

If you have only a casual interest in the skies, or just want a reasonably-priced gift for an astronomy newcomer, you'll love the easy setup and operation of a **Celestron AstroMaster**. These scopes have good optics and sturdy manual mounts that let you find your way around the skies on your own. Each has *two* eyepieces, a red dot finder, manual slow motion controls, steel tripod, computer software that helps you plan your observing sessions, and more.

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2" quartz with 1.25" adapter **189.95**
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The Coronado PST. The best buy in solar observing.

For less than cost of some premium eyepieces, the sub-Ångstrom hydrogen alpha line filter in the **Coronado PST** (Personal Solar Telescope) lets you see the ever-changing drama of solar flares and prominences growing and subsiding before your eyes. The PST, a *2005 Hot Product,* is still a best-seller.

The PST includes a dedicated 40mm refractor with built-in solar filter, a safe built-in Sun finder, and a 20x eyepiece.

The hot Celestron Sky Scout. In stock.

Last fall, it was hard to find the **Celestron SkyScout**. This spring, this *Hot Product for 2007* is still selling like there's no tomorrow, but we have it in stock for you today.

This GPS-based non-magnifying handheld personal planetarium locates and identifies more than 6,000 celestial objects visible to your unaided eye. Earbuds tell you their stories, or you can read the scrolling 5-line text and graphics display. An optional **Orion laser pointer** at $124.95 mounts on the SkyScout to point at sky objects as you identify them. SkyScout makes the night sky as familiar to you as your own back yard.

GPS tells a Meade LX90 where it is . . . so you don't have to!

Meade LX90 8", 10", and 12" go-to Schmidt-Cassegrain telescopes have a GPS (Global Positioning System) that makes it easy for you to find your way to any object in the night sky. The high light transmission of their UHTC multi-coated optics makes sure you see everything there is to see once you get there.

Unlike other telescopes, you don't have to tell your LX90 where or when you are on earth in order to have it find any of the more than 30,000 celestial wonders in its memory. Its built-in GPS receiver gets that information from 24 Earth-orbiting satellites, then moves the scope to two alignment stars – *all automatically!*

Simply check that your LX90's finderscope (it has two, an 8 x 50mm and a red dot) is centered on those stars, then start enjoying the best in 21st century computerized go-to observing at the touch of a button. A Meade LX90 makes astronomy that easy.

Here are the prices on the Meade LX90 scopes that we stock:

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12" LX90-GPS, UHTC optics **3299**

A Telegizmos protects your scope day and night.

The **TeleGizmos Solar Scope Covers**, right, protect your scope from occasional exposure to dew and the sun (such as at star parties). Using a NASA-developed aluminized material originally designed to insulate spacecraft, these multilayer covers are strong, light, and more durable than ordinary Mylar. Solar Scope Cover prices start at only $29.

TeleGizmos 365 Series Covers, left, protect your scope from wind, dust, rain, and the heat of the Sun 24 hours a day, 7 days a week, 365 days a year. These dual-material multilayer covers provide full protection from the elements and start at only $39. See our website for many more cover choices.

Typical **365 Series** full-time cover prices . . .

T3ET, for 3.5" to 5" Meade ETX **$39**
T311, 8" to 11" altazimuth catadioptric **99**
T314, 12" to 14" altazimuth catadioptric ... **119**
T316, 16" altazimuth catadioptric **129**
T3G1, 8" to 10" equatorial catadioptric **139**
T3G2, 11" to 14" equatorial catadioptric .. **149**

Typical **Solar Scope** cover prices . . .

TGET, for 3.5" to 5" Meade ETX **$29**
TGN1, 10" Schmidt-Newt on eq mount **59**
TGG2, 14" catadioptric on eq mount **62**
TGR6-L, 6" refractor on large eq mount **67**
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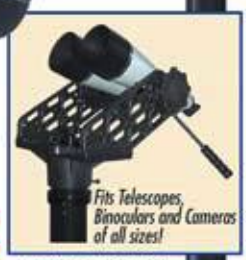

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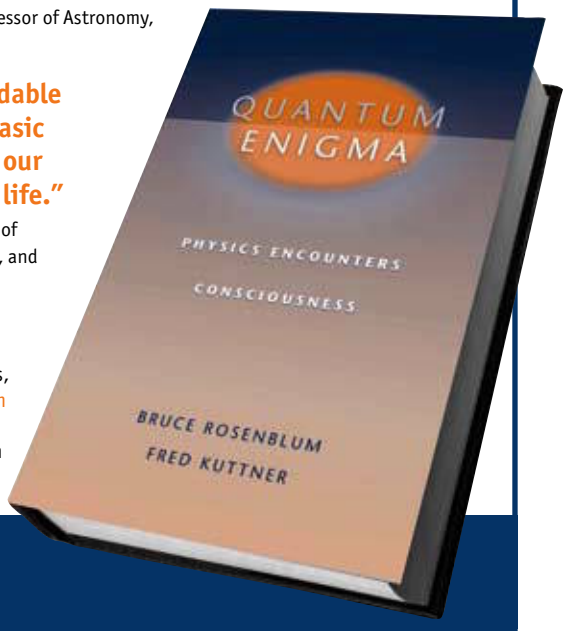

For a summary of the quantum mysteries in 3 short paragraphs, go to www.quantumenigma.com and click on "Nutshell." While you're there, also click on "A Social Responsibility."

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LONG WALK Astronaut Michael Lopez-Alegria completed a 6-hour jaunt outside the International Space Station February 22. It was his tenth spacewalk — a record for a U.S. astronaut.

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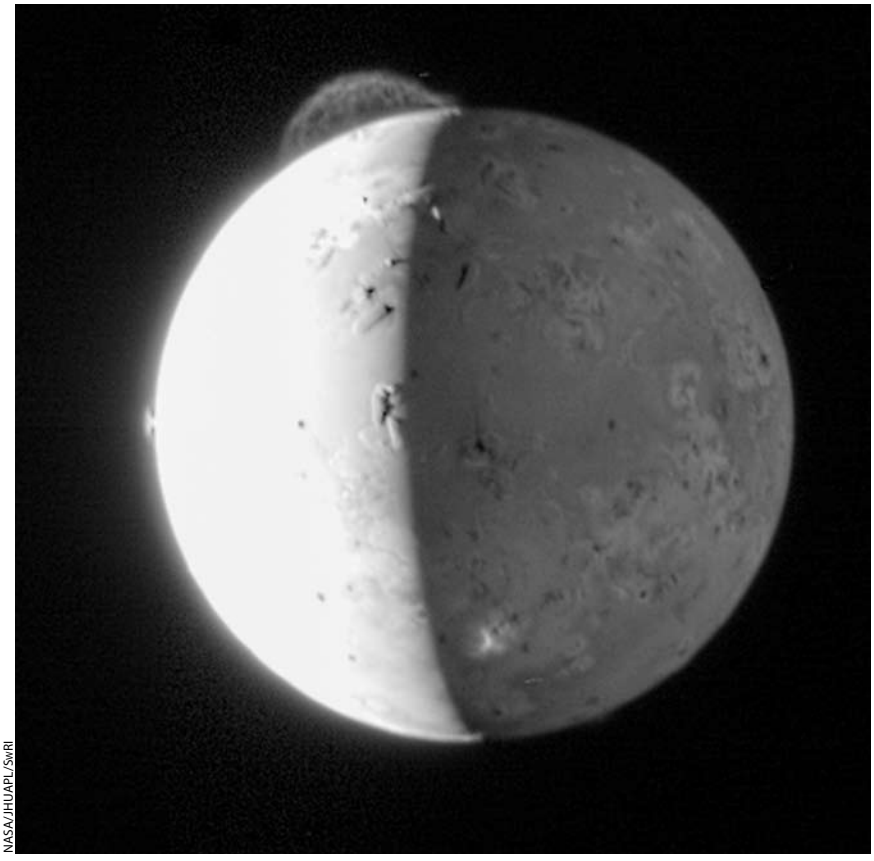

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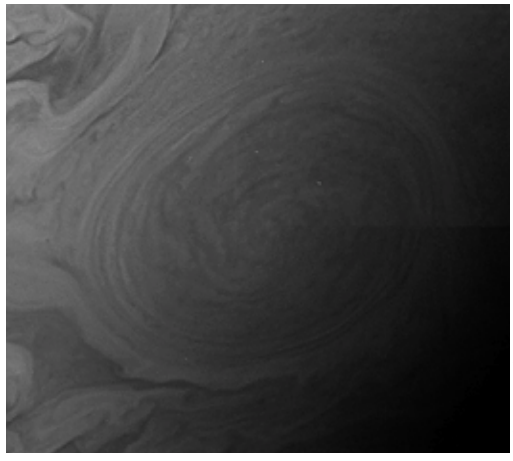

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▲ **SPOT-ON.** The Great Red Spot's smaller cousin, the Little Red Spot, stands front and center in this February 26 image. This spot formed in the past decade when three smaller storms merged.

◀ **YO, IO.** New Horizons took this shot of Jupiter's moon Io February 28, about 5 hours after closest approach. A plume from Tvashtar volcano reaches 180 miles (290 km) high in the 11 o'clock position. A 40-mile-high (60 km) plume erupts from Prometheus volcano at the 9 o'clock position, and a third plume, from Masubi volcano, catches the setting Sun on Io's night side, near the image's bottom.

26 **Inside a planet's atmosphere**

26 **Dawn's early light**

27 **Giant cloud on Titan**

30 **A wicked stellar wind**

New Horizons passes Jupiter test

The fastest spacecraft ever launched from Earth stole a tiny bit of Jupiter's orbital energy February 28, picking up speed as it headed toward Pluto and the unexplored Kuiper Belt beyond. New Horizons came within 1.4 million miles (2.3 million kilometers) of the giant planet, which increased its speed by nearly 9,000 mph (14,000 km/h) and put it on course to reach Pluto in July 2015.

"We designed the entire Jupiter encounter to be a tough test of the mission team and our spacecraft," says New Horizons Principal Investigator Alan Stern of the Southwest Research Institute in Boulder, Colorado. "We're not only learning what we can expect from the spacecraft when we visit Pluto in 8 years, we're already getting some stunning science results at Jupiter — and there's more to come."

New Horizons' instruments imaged Jupiter's turbulent atmosphere, surveyed its dusty rings, mapped the four Galilean moons — Io, Europa, Ganymede, and Callisto — and examined the planet's vast magnetic cocoon. Most of this close-approach science data was sent back to Earth in March and April, after this issue went to press.

New Horizons covered the 500 million miles (800 million km) to Jupiter in little more than a year — faster than any of the previous seven spacecraft to visit the planet. **— RICHARD TALCOTT**

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ESA/ALFRED VIDAL-MADJAR (INSTITUT D'ASTROPHYSIQUE DE PARIS, CNRS, FRANCE)/NASA

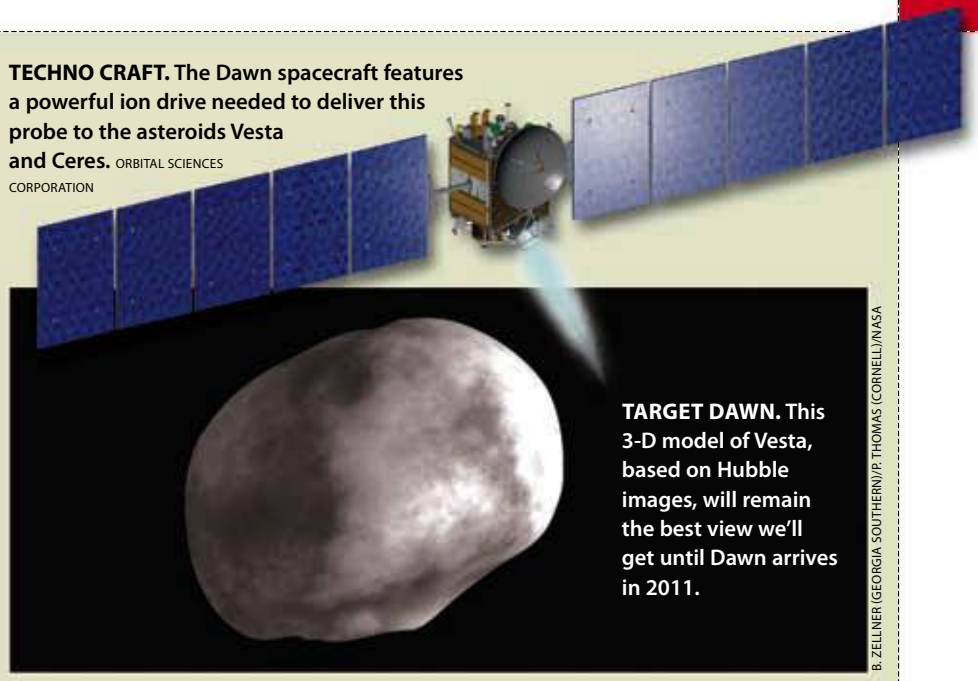
EXTRASOLAR "COMET." **This artwork depicts HD 209458b, a planet orbiting just 4.7 million miles (7.6 million km) from its parent star.**

Inside a planet's atmosphere

For the first time, the Hubble Space Telescope has peered into the atmospheric layers of a planet beyond our solar system. The observations focused on a thin, dense layer of hydrogen — only 620 miles (1,000 kilometers) thick — located in the atmosphere's upper reaches. A team of scientists led by Gilda Ballester of the University of Arizona in Tucson reported its observations in *Nature* February 1.

The planet, dubbed HD 209458b, orbits 10 times closer to its parent star than Mercury orbits the Sun. Intense radiation boils 10,000 tons of gas per second from this "hot Jupiter" into space, leaving a comet-like exhaust trail behind the planet. The team could analyze HD 209458b's atmosphere because it is one of the few known exoplanets that transits its star.

Other astronomers using the Spitzer Space Telescope were surprised to see no sign of water in the planet's infrared spectrum. Theory says the water should exist, and astronomers suspect it is hidden beneath a dusty layer, also revealed by the spectrum. **— DANIEL PENDICK**



TECHNO CRAFT. **The Dawn spacecraft features a powerful ion drive needed to deliver this probe to the asteroids Vesta and Ceres.** ORBITAL SCIENCES CORPORATION

TARGET DAWN. **This 3-D model of Vesta, based on Hubble images, will remain the best view we'll get until Dawn arrives in 2011.**

B. ZELLNER (GEORGIA SOUTHERN)/P. THOMAS (CORNELL)/NASA

Dawn to probe asteroids

The Sun nearly set on NASA's Dawn mission a year ago, when the space agency canceled it over concerns with its ion engine. The mission is designed to study two large asteroids: Vesta and Ceres. After a review of planned ion-engine improvements, however, NASA revived the project. Now set for launch in late June, the probe will visit these two minor planets while carrying some major hardware features: the most powerful electrical and propulsion systems ever installed on an interplanetary spacecraft.

The probe will use an ion-drive system with xenon propellant tested on the Deep Space 1 interplanetary mission (1998–2001). The three steerable ion engines will operate for half of the planned 10-year mission. The system has enough propellant to change velocity by 22,000 mph (36,000 km/h) — far higher than any previous interplanetary spacecraft and bigger than the total impulse delivered by the Delta-II launch vehicle.

Dawn carries solar arrays that span 65 feet (20 meters) and generate 10 kilowatts at Earth's distance from the Sun — 4 times as powerful as the arrays on Deep Space 1. This electricity is used to ionize the xenon atoms and accelerate the ions, powering the spacecraft. Dawn also has a set of hydrazine-fueled attitude-control thrusters for orienting the probe in space.

Dawn's low-thrust trajectory will spiral out from the Sun. The craft will fly past Mars in March 2009 for a gravity assist (which could be skipped if launch conditions are right, lengthening the stays at each asteroid).

Dawn will arrive at Vesta in October 2011 for a 6-month visit. It will then head for Ceres, arriving in February 2015. This particular Mars-Vesta-Ceres trajectory won't repeat for another 15 years, so a launch by October 2007 is crucial.

The ion engine also lowers the spacecraft into a 435-mile-high (700 km) survey orbit of each target asteroid, then lowers the orbit's closest point to about 45 miles (75 km) for high-resolution imaging. All this while, the spacecraft will search for navigation hazards, such as small moons and dust.

Dawn carries cameras as well as instruments to determine the asteroids' surface compositions. Mission leaders had to abandon earlier plans to carry a magnetometer and a laser altimeter.

Astronomers think about 5 percent of meteorites come from Vesta. The asteroid's surface appears covered with basaltic lava flows, and a massive impact basin lurks at its south pole. Ceres shows evidence of a primitive surface and a thin atmosphere, with seasonal frost deposits. Rock and dust possibly cover a thick layer of water ice.

There's nothing minor about the discoveries planetary scientists expect to find at these relics from the solar system's birth. **— JAMES OBERG**

MICROTECH Scientists have created "microshutters" for the James Webb Space Telescope. The hairs'-width shutters will mask unwanted light from foreground objects.

ESA/NASA/J. KNEIB (LABORATOIRE D'ASTROPHYSIQUE DE MARSEILLE)

COMET GALAXY. The oddly shaped galaxy in the upper left of this Hubble image leaves a trail of gas and stars as it plows through the distant galaxy cluster Abell 2667.

How galaxies run out of gas

The current universe boasts a roughly equal number of gas-poor elliptical galaxies and gas-rich spiral and irregular galaxies. Yet, when the cosmos was half its present age, 80 percent of galaxies had plenty of gas and the robust star formation that goes with it. What happened?

Astronomers have long suspected galaxy transformation takes place in the harsh environment of galaxy clusters. Now, using the keen eyes of Hubble and several other ground- and space-based telescopes, a research team led by Luca Cortese of Cardiff University in Wales has found a striking example of this metamorphosis.

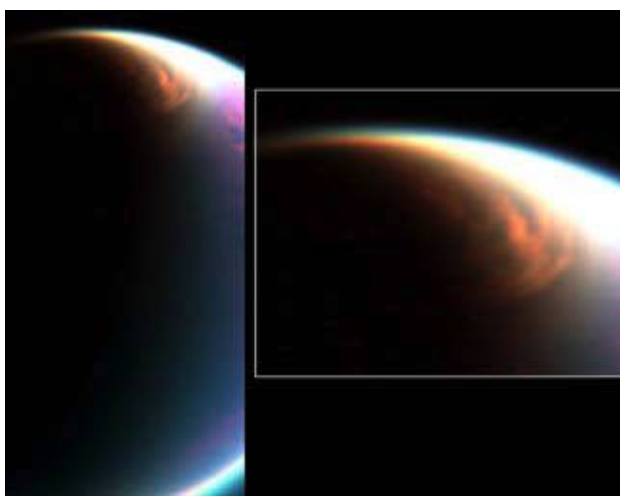
The team found an odd-looking spiral galaxy while observing Abell 2667, a rich cluster some 3.2 billion light-years from Earth. The cluster's enormous mass accelerates the galaxy to about 2.2 million mph (3.5 million km/h), and tidal forces strip away the spiral's stars and gas. In addition, the cluster's hot plasma (tens of millions of degrees) exerts a "ram pressure" that hastens the losses.

The researchers estimate the strange galaxy is roughly 200 million years along its billion-year journey to total gas loss. They will report their findings in a future issue of *Monthly Notices of the Royal Astronomical Society.* — **R. T.**

Giant cloud on Titan

During a December 29, 2006, flyby of Titan, the Cassini spacecraft snapped a picture of a giant cloud draped across the north polar region of Saturn's largest moon.

The cloud, extending deep into Titan's northern latitudes, is about 1,500 miles (2,400 kilometers) in diameter — wide enough to reach from New York to Texas. Computer models of Titan's atmosphere anticipated such clouds could form, but this is mission scientists' first detailed look.



NASA/JPL/UNIVERSITY OF ARIZONA

CLOUDY WEATHER. Cassini snapped this image of a giant cloud near Titan's north pole. Hydrocarbon "rain" from the cloud may fill surface lakes imaged by the spacecraft's radar.

Data from Cassini's Visual and Infrared Mapping Spectrometer indicate the cloud contains ethane, methane, and other organic compounds — just the stuff needed to fill the northern hydrocarbon lakes seen by Cassini's radar. Some lake levels on Titan appear to be low, perhaps due to evaporation. The cloud suggests a global exchange exists between Titan's surface and atmosphere, with hydrocarbons raining down on the surface and then evaporating back into the air, just as seen with Earth's hydrological (water) cycle. — **D. P.**

QUICK TAKES

ROVER MILESTONE
On February 6, the Mars rover Opportunity's odometer passed 10,000 meters (6.2 miles), nearly 17 times the maximum distance the robot was supposed to cover during its mission.

COROT'S FIRST LIGHT
The French COROT satellite saw first light January 17. The observatory will search for extrasolar planets.

LOST DOG
The Mars Reconnaissance Orbiter's HiRISE camera failed to locate ESA's Beagle 2 lander. A previous search hinted the craft crashed in a crater.

RECORD SETTER
INTEGRAL, ESA's gamma-ray observatory, has discovered the fastest-spinning neutron star known. Cataloged as XTE J1739–285, the object rotates 1,122 times per second.

RETURN TO SOL
Ulysses flew above the Sun's south pole February 7, the third time this 16-year-old solar probe has done so.

DARK CLOUDS
Computer models show night clouds may explain why the martian tropics are some 35° F (20° C) warmer than climate models predicted.

SPARKY MOON
Thousands of volts of static electricity charge the Moon's surface. Sparks from static discharge could endanger astronauts' equipment.

DIG DEEP FOR MARTIANS
A team of astrobiologists has concluded cosmic radiation would kill any living cell on Mars within several yards (meters) of the surface.

HOT ICECUBE
The IceCube Neutrino Observatory in Antarctica exceeded construction goals last summer. The scope should be completed in 2011.

WHAT A BLAST
On January 30, a booster rocket exploded at liftoff on a floating platform in the equatorial Pacific, destroying a Dutch satellite.

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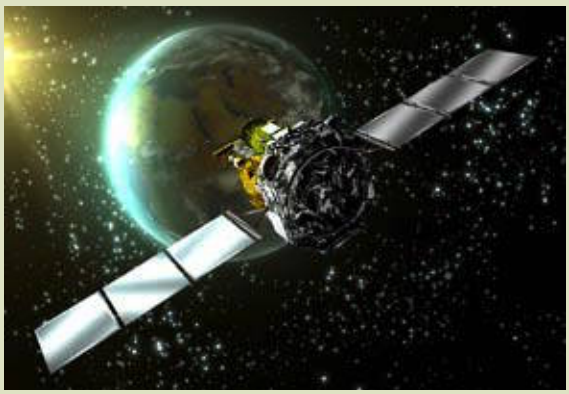
Cocooned binary stars



ESA

HIDDEN STARS. The Earth-orbiting INTEGRAL spacecraft has found 20 binary systems obscured by gas and dust.

French scientists attending the first GLAST Science Symposium February 5–8 at Stanford University in Palo Alto, California, announced new findings about an exotic class of objects: odd couples comprising zippy little neutron stars orbiting supergiant companions. The scientists have discovered 20 of these objects since 2003 with the INTErnational Gamma-Ray Astrophysics Laboratory (INTEGRAL).

These binaries are hard to see because the supergiant star ejects gas and dust, creating an obscuring cocoon. However, by combining INTEGRAL data with observations from the ground, the French team was able to peer through the cocoon.

The neutron stars produce the intense X rays seen by INTEGRAL as they sweep through the cocoons. Yet the gas and dust is so dense, it absorbs most X rays. European Southern Observatory telescopes in Chile showed the cocoons glow strongly at infrared wavelengths — a tip-off that the gas and dust are heated from within.

Scientists may discover more of the cocooned binary systems once the Gamma-ray Large-Area Space Telescope (GLAST) launches later this year. — **D. P.**

25 years ago in *Astronomy*

June 1982

Martin Cohen's "The Vanishing Act of Red Giants" looked at how main sequence stars evolve into red giants, whose tremendous sizes more than offset their low surface temperatures. Cohen referred to red giants as "stellar embarrassments," created by running out of hydrogen fuel.

June 1982 also found *Astronomy* puzzling over the history and properties of light in "The Electromagnetic Spectrum." Harry Augensen and Jonathan Woodbury explained that light from space consists of coded messages that give astronomers clues about the physical processes of the universe. Today, advanced space telescopes scour the sky at most wavelengths to reveal details in objects near and far.

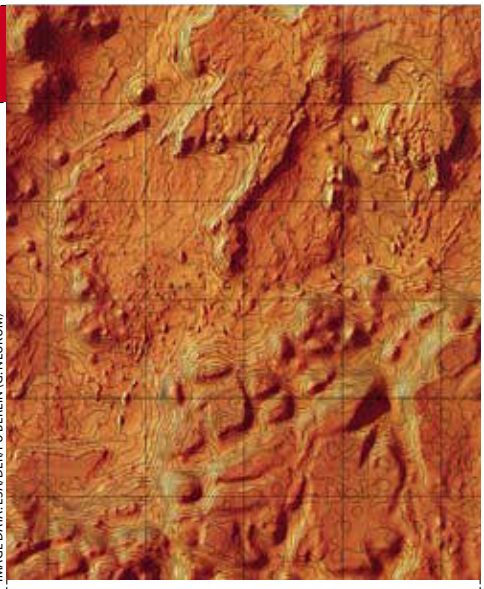
10 years ago in *Astronomy*

June 1997

In June 1997, *Astronomy* took its readers on a virtual tour of the "Enchanted City" of La Silla, the first European Southern Observatory (ESO) built in Chile. Bordering the Atacama Desert, La Silla sits atop a 7,700-foot (2,400 meter) mountain and boasts a dry environment, little air turbulence, and clear skies on 80 percent of nights.

In 1997, the mountain was home to the Vesta Team, a group of astronomers studying the surface structure and composition of the asteroid Vesta. Also in residence that year were astrophysicists with the French EROS II project, a study of MAssive Compact Halo Objects, or MACHOs — planet- and stellar-mass objects that reside in the Milky Way's halo.

The original members of ESO, created in 1962, included Belgium, France, Germany, the Netherlands, and Sweden. Denmark, Italy, Switzerland, Portugal, and the United Kingdom joined later. La Silla remains an important observatory, although only six telescopes remain in use. ESO currently devotes more attention, and money, to its telescopes on Cerro Paranal. — **KATIE NEUBAUER**



MAP COMPILATION: TECHNISCHE UNIVERSITÄT BERLIN, 2006; IMAGE DATA: ESA/DLR/FU BERLIN (G. NEUKUM)

CHAOTIC LANDSCAPE. Using data from the Mars Express orbiter, scientists have created topographic maps of Iani Chaos. Contour lines show altitude differences of just 160 feet (50 meters).

Take a (Mars) hike

Scientists with the European Space Agency's Mars Express orbiter mission have created the first detailed "hiker's maps" of the martian surface. These topographic maps are identical to those hikers on Earth use to navigate terrain. The maps are prototypes for a proposed global mapping project that would result in 10,372 "topo" maps covering the planet's entire surface.

The researchers, headed by Gerhard Neukum of the Freie Universität in Berlin, couldn't have chosen a more topo-worthy spot for their first maps: Iani Chaos. The region, about 270 miles (430 kilometers) wide and 200 miles (330 km) long, is a knobby jumble of basins, terraces, canyons, and hills. Scientists think Iani Chaos might have formed when ice beneath a formerly even surface melted from volcanic heat, causing the surface to collapse.

Neukum and his colleagues made the maps using software they designed to do cartography based on data from Mars Express' High-Resolution Stereo Camera. — **D. P.**

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DIRECT HIT. Deep Impact crashed into Tempel 1 July 4, 2005. The dust released implies this comet formed after Hale-Bopp.

A comet comparison

Comet scientists are starting to make sense of data gleaned from Deep Impact's 2005 crash into Comet Tempel 1 and teased from particles returned in 2006 by the Stardust spacecraft from Comet Wild 2. Although they've found comets have many similarities, they also show significant differences.

Carey Lisse of Johns Hopkins University's Applied Physics Laboratory headed a team that used the Spitzer Space Telescope to watch the Deep Impact collision. Lisse also led a team comparing Tempel 1's composition with Comet Hale-Bopp's.

Dust from Tempel 1 appears more processed than that from Hale-Bopp, suggesting Tempel 1 formed later. "Either Tempel 1 is much different than other comets because it formed later, out of stuff that had been baked and broiled more by the young Sun and shock waves made when the giant planets formed, or the material in the comet has changed over time more than for other comets," says Lisse. The team's findings will appear this August in *Icarus*.

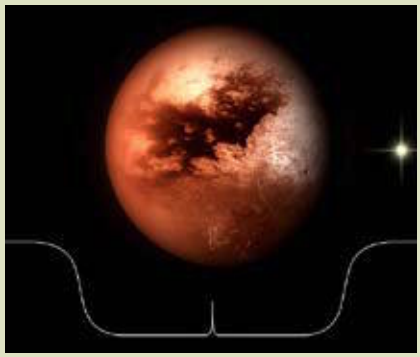
Meanwhile, researchers studying Comet Wild 2 samples remain surprised that the comet may not have been born in the outer solar system. "We basically found solids that formed in the hottest possible regions of the solar nebula, and we found them in the coldest possible place," says Stardust's principal investigator Don Brownlee of the University of Washington. **— L. L.**

Star probes Titan's air

More than a year before the Huygens probe reached Saturn's largest moon, Titan, astronomers caught a lucky break when Titan passed in front of two distant stars within 7.5 hours November 14, 2003. The pair of occultations helped the scientists investigate the upper layers of Titan's atmosphere.

"Titan's atmosphere acts like a lens, so at the very middle of an occultation, a bright flash occurs," says Bruno Sicardy of the Paris Observatory in France. The flash's shape shows Titan's atmosphere was flattened at the north pole.

Sicardy's team also found a fast-moving wind more than 125 miles (200 kilometers) above Titan's surface at a latitude of 50° north. The wind, similar to Earth's jet stream, traveled at 450 mph (720 km/h). The findings are helping Huygens' scientists understand the probe's descent. **— L. L.**



ESA/C. CARREAU

LIGHT TRICK. Titan's atmosphere blocks a star's light during an occultation. A light curve (bottom) shows the light dimming as it passes through air, and a spike in the middle when the air acts like a lens.

BRIEFCASE

New engine

A prototype engine developed by Georgia Tech researchers uses ion-propulsion technology and solar power to maximize fuel efficiency, increase payloads, and reduce the cost of launching satellites. The new engine uses about 40 percent less fuel by running on solar power and accelerating ionized xenon atoms. **— L. L.**

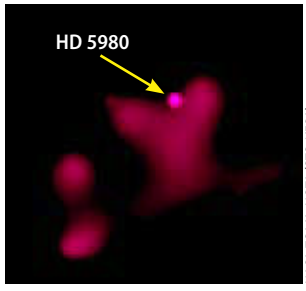
To Mercury

Europe plans to launch its BepiColombo spacecraft on a 6-year trip to Mercury in August 2013. Two satellites will explore the inner planet for at least 1 Earth year. **— L. L.**

First light

The South Pole Telescope saw first light February 16. Astrophysicists will use the 33-foot-wide (10 meters), 280-ton scope to investigate dark energy. The South Pole's extremely cold and dry air suits the first project: to detect slight variations in the cosmic microwave background radiation to learn whether dark energy affects galaxy-cluster formation. **— L. L.**

A wicked stellar wind



NASA/ESA/A. NOTA (STScI/ESA)

COLLIDING WINDS. HD 5980 is one of the brightest X-ray sources in the neighboring Small Magellanic Cloud.

Observations from Earth's premiere X-ray observatories reveal a gale blowing in the Small Magellanic Cloud. An international team of astronomers led by Yaël Nazé of the University of Liège in Belgium used ESA's XMM-Newton and NASA's Chandra satellites to view a binary system with two humongous stars, one 50 and the other 30 times the Sun's mass, orbiting each other at about half the distance between Earth and the Sun.

The stars radiate more energy every minute than our home star emits in a year, buffeting each other with supersonic stellar winds. Both XMM-Newton and Chandra detected the bright X-ray glow created by the colliding winds.

Chandra saw the X-ray glow in 2001. Additional observations with XMM-Newton found its origin to be gas heated as each star blowtorches the other. The X-ray emissions from this so-called colliding-wind binary rise and fall as the stars orbit each other every 20 days and periodically eclipse each other. This is the first colliding-wind binary seen outside the Milky Way. The observations were published online February 16 by *The Astrophysical Journal*. **— D. P.**

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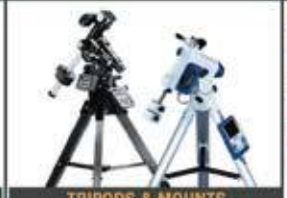
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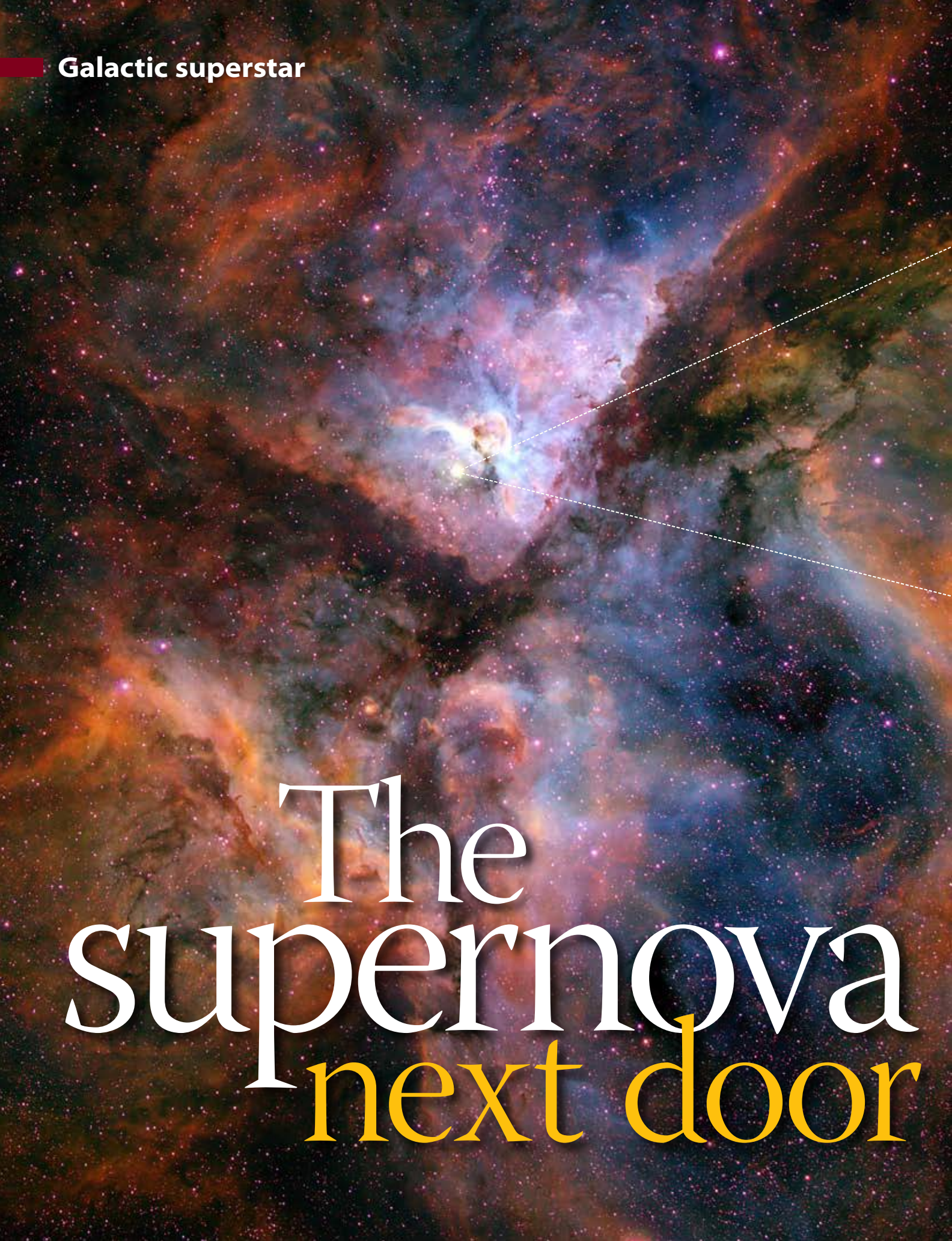
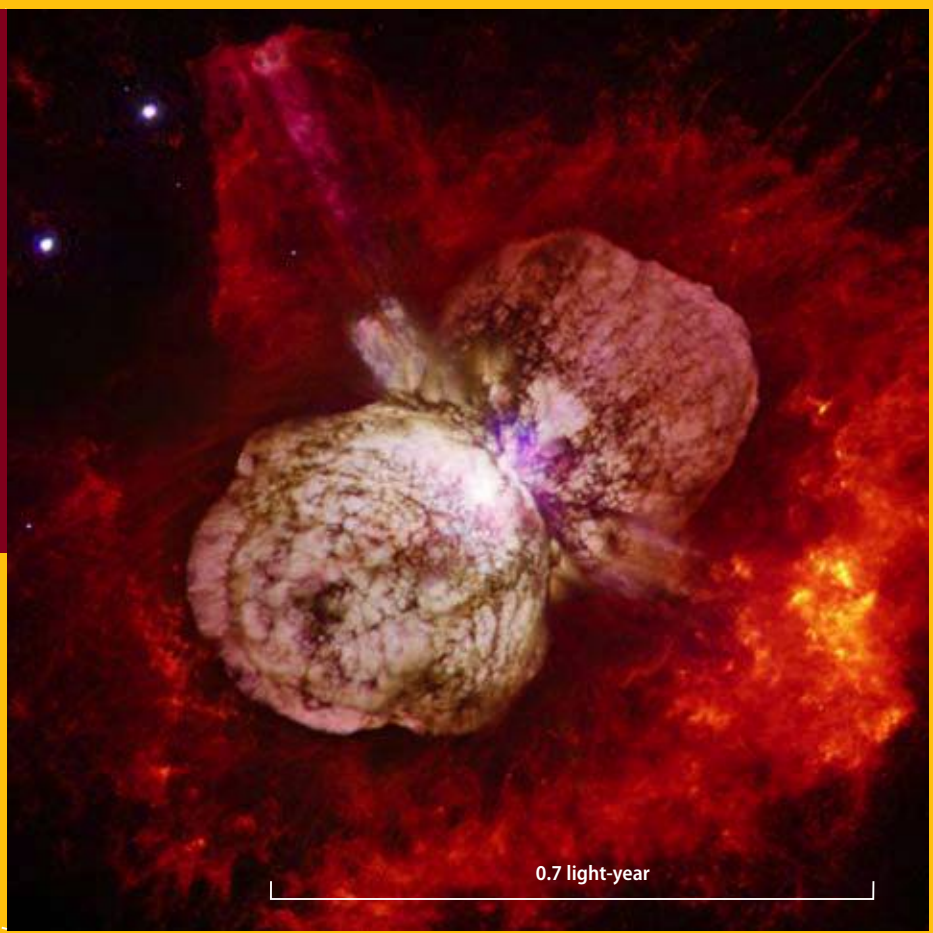


The supernova next door

◀ **THE CARINA NEBULA,** seen here in false color, is a giant star-forming region 7,500 light-years away. It's home to Eta Carinae, one of the most massive and luminous stars known. NOAO/AURA/NSF/NATHAN SMITH (UNIV. OF MINNESOTA)

▶ **THE HOMUNCULUS,** Eta Carinae's spectacular bipolar nebula, was ejected during the star's Great Eruption in the 1840s. The nebula contains 12 or more times the Sun's mass of gas and dust and expands at some 1.5 million mph (2.3 million km/h). NASA/ESA NATHAN SMITH AND JON MORSE (UNIV. OF COLORADO)



Eta Carinae's massive eruptions warn the superstar's explosive destruction may come sooner than suspected.

/// **BY FRANCIS REDDY**

Eta Carinae is among the most massive, luminous, and violent stars known. With a mass estimated at 100 Suns or more, astronomers know Eta Carinae one day will explode as a spectacular supernova. Now, say scientists, clues from material cast off the star thousands of years ago suggest that catastrophic day may come sooner rather than later.

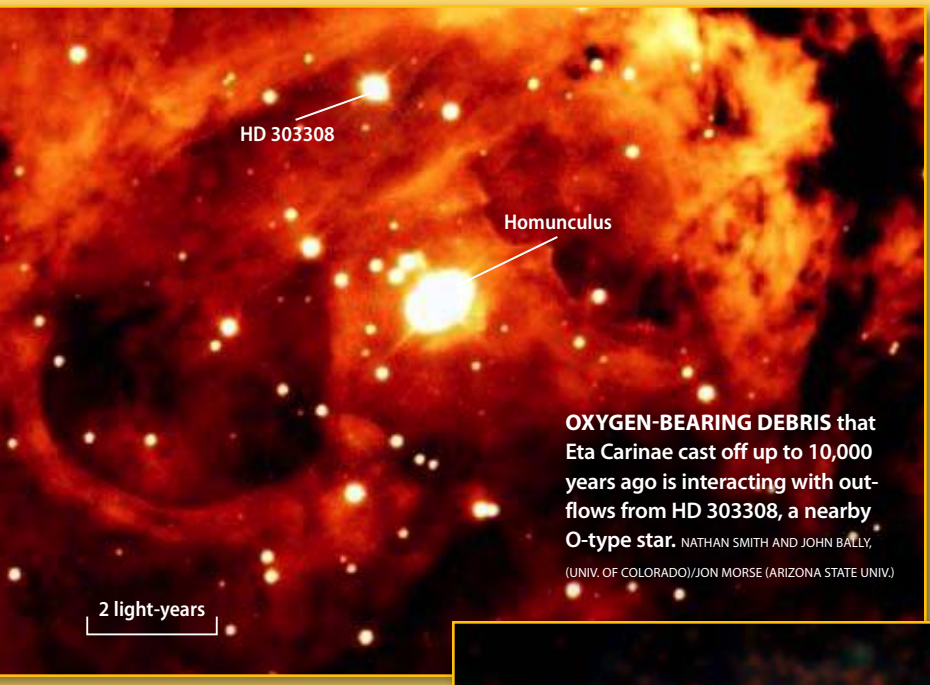
Eta Carinae lies in the southern constellation Carina about 7,500 light-years away. "If it were in the Northern Hemisphere, its dramatic changes would have made it the most famous star in the sky," says astronomer John Martin at the University of Illinois in Springfield.

While 19th-century astronomers were familiar with the star's erratic brightness changes, they were stunned in 1842 when Eta Carinae briefly outshone every star except Sirius. During this Great Eruption, the star hurled a dozen solar-masses into space — about twice the Sun's mass each year. Yet, Eta Carinae survived this outburst — and erupted again 50 years later.

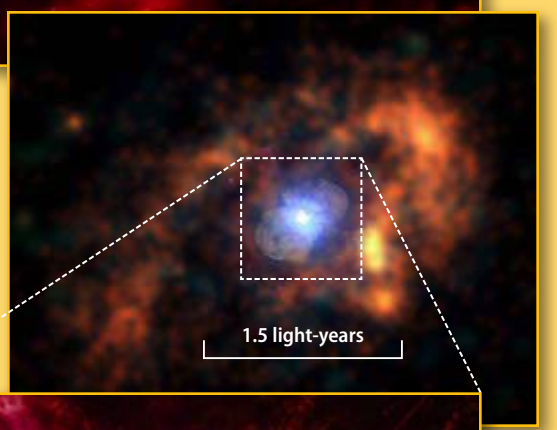
Eta Carinae radiates some 5 million times the Sun's energy. Dust in the ejected matter dims most of the star's light but

Francis Reddy *is an associate editor of* Astronomy.

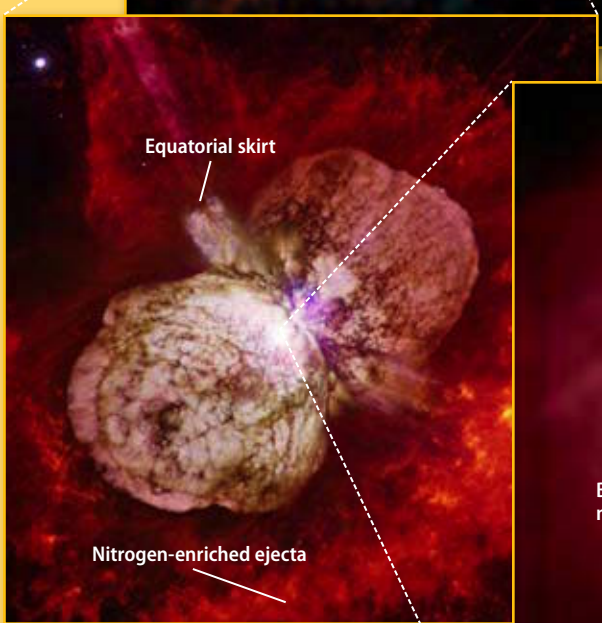
Zoom into Eta Carinae



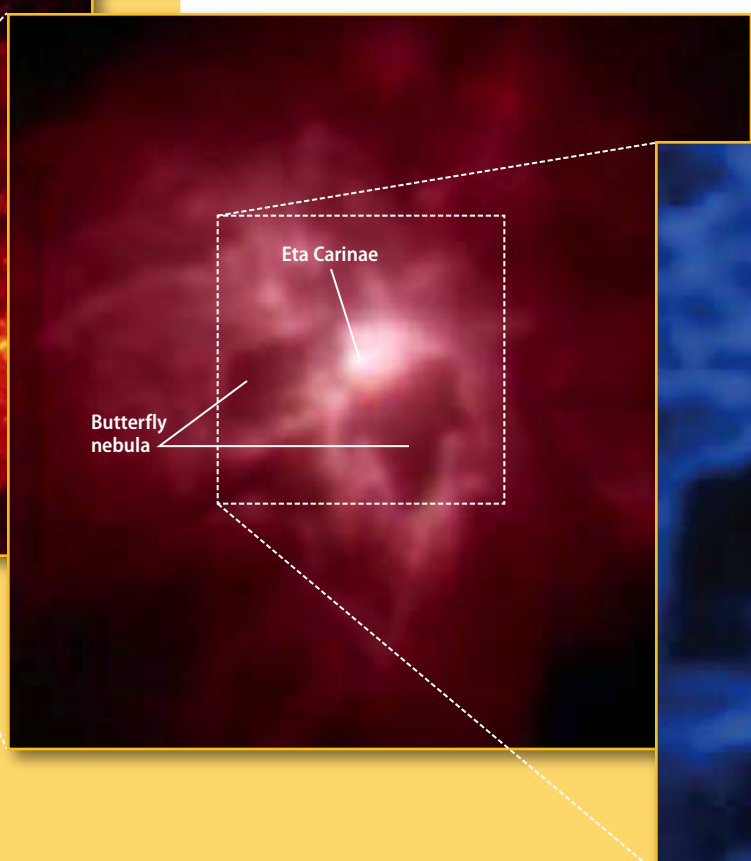
OXYGEN-BEARING DEBRIS that Eta Carinae cast off up to 10,000 years ago is interacting with outflows from HD 303308, a nearby O-type star. NATHAN SMITH AND JOHN BALLY, (UNIV. OF COLORADO)/JON MORSE (ARIZONA STATE UNIV.)



▶ **X RAYS ARISE** from shocked material in a 2-light-year-wide region around Eta Carinae. This view from NASA's Chandra X-ray Observatory includes a superimposed optical image of the Homunculus. NASA/CXC/SAO



▶ **THE HOMUNCULUS** contains gas and dust blown from Eta Carinae's poles in the 1840s. The structure tips about 41° to our line of sight. Observations using the Hubble Space Telescope reveal a "skirt" of equatorial ejecta between the lobes. A nitrogen-rich shell surrounds the nebula. NASA/ESA/NATHAN SMITH AND JON MORSE (UNIV. OF COLORADO)



▶ **INFRARED INSTRUMENTS** on the European Southern Observatory's Very Large Telescope in Chile peered into Eta Carinae's dusty heart in 2002 and 2003. The star occupies a clear zone within a butterfly-shaped dust complex. ESO/OLIVIER CHESNEAU ET AL.

re-radiates the energy it absorbs as heat. This makes the star the brightest object outside the solar system in the mid-infrared part of the spectrum, between 3 and 20 microns. It's so bright, NASA's Spitzer Space Telescope can't even slew past the star, let alone observe it. "Eta would just heat up the detector and probably boil off some of the cryogens that cool the telescope and make it so sensitive," says Nathan Smith at the University of California, Berkeley.

Astronomers class Eta Carinae as a Luminous Blue Variable (LBV). For reasons unknown, these rare, hot, massive stars erupt violently with brightness increases that rival supernovae. Roberta Humphreys at the University of Minnesota often calls them "supernova impostors." As the closest LBV, Eta Carinae gives scientists a ringside seat for observing such behavior.

Spectacular images from NASA's Hubble Space Telescope show Eta Carinae embedded in a rapidly expanding, twin-lobed nebula about 0.7 light-year long. Containing 12 or more times the Sun's mass of gas and dust, the nebula expands at 1.5 million mph (2.3 million km/h). Enrique Gaviola of Argentina's Córdoba Observatory, whose images in the 1940s first revealed the nebula, dubbed it the Homunculus ("little man") for its telescopic appearance.

In the past, Humphreys says, the nebula resembled a Pillsbury Doughboy or Michelin Man in the telescope, but it has

changed. When Gaviola observed the Homunculus, the star was too faint to see with the naked eye. In the early 1950s, Eta Carinae began a long-term brightening trend that returned it to the rank of visible stars. Now at 5th magnitude, the star's glow all but swamps the surrounding nebulosity.

The prevailing view is that Eta Carinae's brightening results from a thinning of dust in our line of sight. The star now sheds about 1/1,000 the Sun's mass — more than 300 Earth-masses — each year. This outflow is so dense, it masks the star's visible surface and makes it appear cooler than it really is. What appears to be Eta's visible surface is really the point where the stellar wind's density drops enough for light to escape. The star's apparent temperature is between 15,000 and 30,000 kelvins, or up to 5 times hotter than the Sun.

Using Hubble's high-resolution Space Telescope Imaging Spectrograph (STIS), Smith led a team that determined Eta Carinae to be shaped like a peanut, its long axis aligned with the Homunculus. "We used reflected light from the Homunculus to look at the star from multiple directions at the same time," he explains. "Aside from the Sun, we've never been able to view any other star from multiple latitudes in this way."

In 2001, a team of astronomers led by the University of Amsterdam's Roy van Boekel measured the star's size, shape, and orientation using an interferometer on the Very Large Telescope (VLT) at the European Southern Observatory (ESO) in Chile. "There's a reason the Homunculus looks the way it does," Martin says. Eta's "peanut" is so large that, placed in the center of our own solar system, it would engulf all the planets out to Jupiter.

Smith, Kris Davidson at the University of Minnesota, and other astronomers suspect Eta Carinae's activity over the past 160 years reflects stages in its recovery from the Great Eruption. "The star threw off 10 to 15 percent of its mass — and survived. How does it recover from something like that?" Martin asks. "You have to totally reorganize the pressure, temperature, and density structure inside that star to get something stable again." Indeed, observations hint the star goes through some kind of adjustment every 50 years or so (see "Eta Carinae on the rise," p. 36).

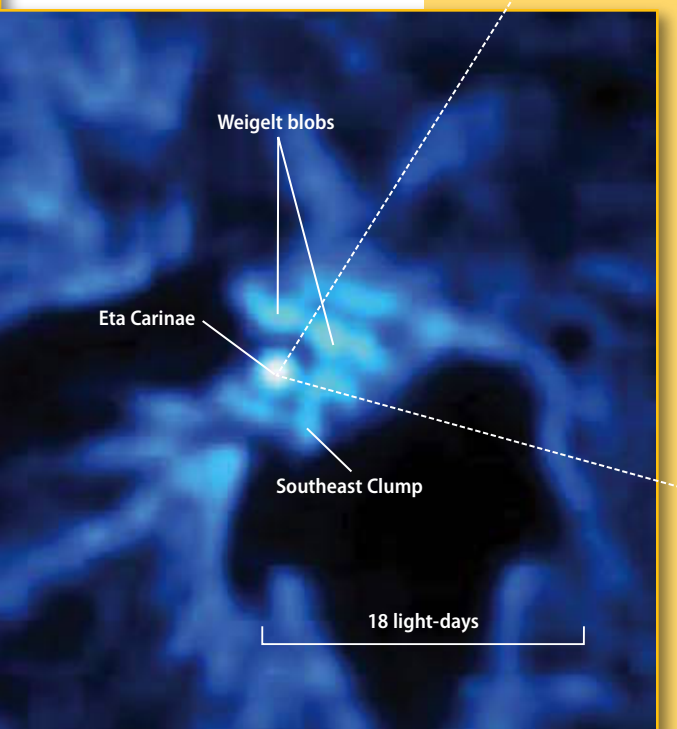
Eta Carinae's surface temperature and rotation may change as it restores balance, and these properties, in turn, alter its stellar wind. The wind affects dust production around the star. When the dust production drops, the star appears to get brighter because more light gets out. If this is what's happening — and if the trend continues — Martin suggests astronomers may soon get their clearest view of Eta Carinae since its Great Eruption. "On the other hand," he says, "maybe this is just a little shift in a much longer recovery process, and the brightening might level off."

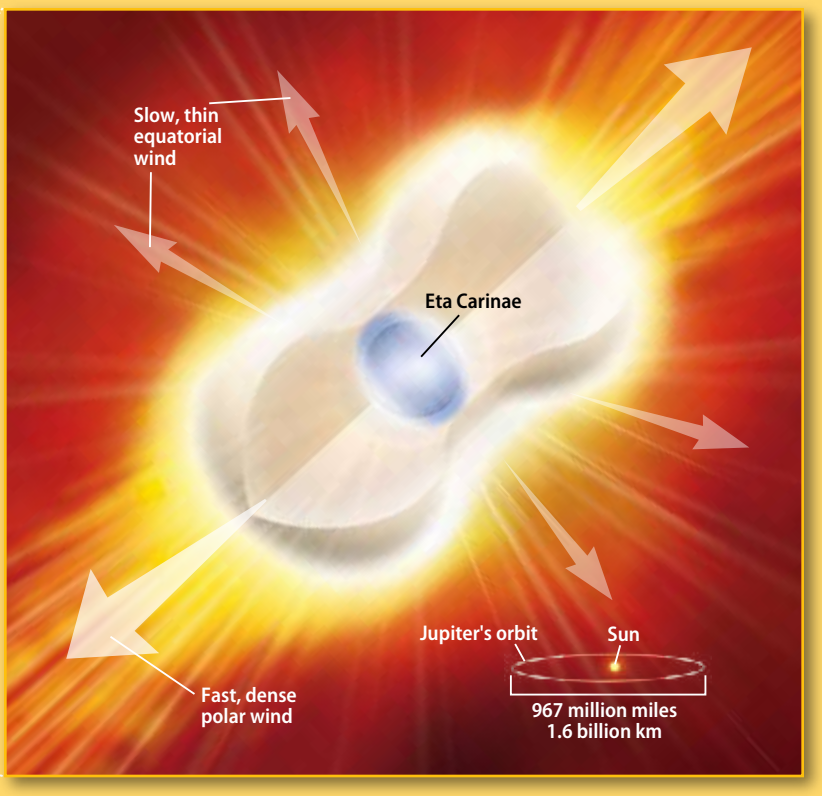
Quick-change artist

Looking at Eta Carinae's spectrum today, astronomers see a dense forest of bright emission lines indicating highly excited gas, most notably neon, iron, and helium. But this is relatively recent behavior, Humphreys concludes after examining spectra taken between 1892 and 1942 in the Harvard College Observatory collection. These lines first appeared in spectra Gaviola obtained in 1944.

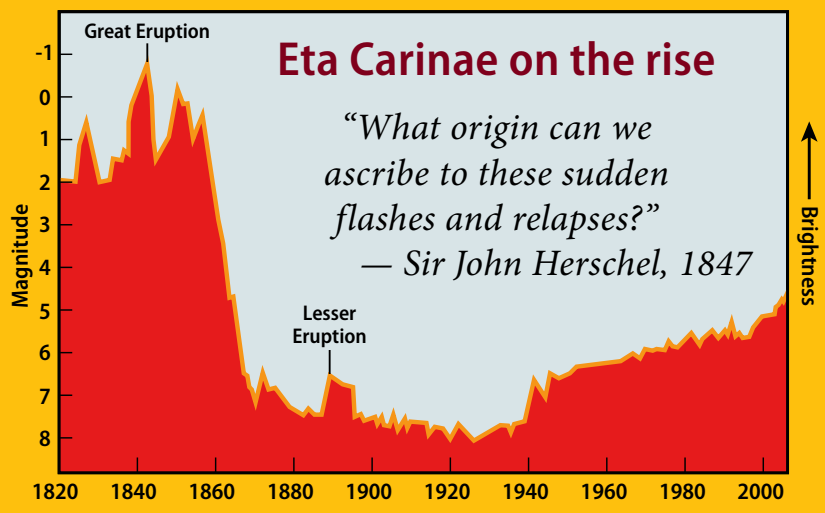
Four years later, Gaviola noticed something else: The high-excitation lines briefly weakened. Astronomers subsequently saw several similar fade-outs, some associated with changes at X-ray and radio wavelengths. But it took Augusto Damineli at the Institute of Astronomy and Geophysics in São Paulo, Brazil, to put them together. In 1996, he recognized these "spectroscopic events" occurred 5.5 years apart and

▶ ETA CARINAE'S outflow is so dense, it's opaque near the star. Placed at the center of our solar system, the star would engulf Jupiter's orbit. *ASTRONOMY:* ROEN KELLY





◀ THE BEST LOOK into Eta Carinae reveals infrared details just a few light-days across. Gas clouds known as Weigelt blobs, first discovered in the 1980s, contain silicate dust, while an area called the Southeast Clump is rich in aluminum oxide. ESO/OLIVIER CHESNEAU ET AL.



ETA CARINAE'S UNPREDICTABLE brightness changes continue to challenge astronomers. Clearing dust near the star may explain its most recent rise. *ASTRONOMY:* ROEN KELLY

FOLLOW THE UPS AND DOWNS OF A PUZZLING STAR

From 1700 to 1800, Eta Carinae brightened from 4th to 2nd magnitude. Then, beginning about 1837, the star began its Great Eruption. In 1842, it briefly peaked at –1.0, outshining every star except Sirius. Eta Carinae remained one of the sky's brightest stars for 20 years.

After 1858, as the dusty Homunculus Nebula enshrouded the star, Eta faded below 7th magnitude and became invisible to the unaided eye. After a second, less energetic eruption between 1887 and 1900, the star's apparent brightness fell to near magnitude 8.

There it stayed until the 1940s, when Eta Carinae underwent some kind of change. The star has been brightening steadily since the 1950s, probably as a result of thinning dust.

"It isn't clear if this trend will continue for much longer," says John Martin at the University of Illinois, Springfield. "It all depends on what is actually happening to the star." And that, he admits, no one really knows. — *F. R.*

suggested this represented the orbital period of an unseen companion star.

Damineli suggests spectral-line strengths and near-infrared, X-ray, and radio emissions decrease when a hot companion star passes through the primary's thick stellar wind. This screens out radiation arising from a zone where the stars' stellar winds collide.

Using the Hubble Space Telescope before, during, and after the 2003 spectroscopic event, Nathan Smith and his colleagues tracked ultraviolet bright spots and shadows that suggest a moving, secondary radiation source. But Smith says determining an orbit for the unseen companion that's consistent with all other observations remains a formidable task. Astronomers will gear up for another all-out observational effort at the next event, due in 2009.

Meanwhile, scientists using NASA's Far Ultraviolet Spectroscopic Explorer (FUSE) satellite claimed the direct detection of Eta Carinae's companion in November 2005. But last year, Davidson and Smith showed there's no clear proof FUSE saw the secondary star. The FUSE observations, they say, almost certainly represent the primary star's dense wind.

Thanks to Hubble studies, astronomers know these high-excitation spectral lines arise in three knots of gas called Weigelt blobs. Astronomers have since found other, similar features. Smith and his colleagues conclude the star ejected these gas blobs during its smaller 1890 eruption. But why their spectra began exhibiting cyclic changes only in 1944, no one knows.

What lies beneath

Astronomers' most detailed views of Eta Carinae's environs come from infrared images from ground-based telescopes. Using instruments on ESO'S VLT in 2002 and 2003, a team led by Olivier Chesneau at the Max Planck Institute for Astronomy in Heidelberg, Germany, peered deeply into the Homunculus' central region.

Eta Carinae resides within a butterfly-shaped dust cloud about 300 billion miles (500 billion kilometers) across. But the star lies in a clear zone spanning about 200 times the distance to Neptune in our solar system. Eta's strong wind buffets the butterfly nebula's inner edges, where the combination of high temperature and density may favor dust formation.

The observations found nebula regions rich in corundum — aluminum oxide, the same stuff that makes rubies and sapphires. Astronomers say it's one of the first types of dust to form in a harsh environment. Farther out, in the Weigelt blobs, the team detected a rich store of silicate dust.

"These beautiful images show surprisingly complex structures that reveal important clues to the nebula's geometry," Smith says, "but that complexity can be difficult to interpret." It isn't always clear how the infrared structures correspond to those seen in visible light.

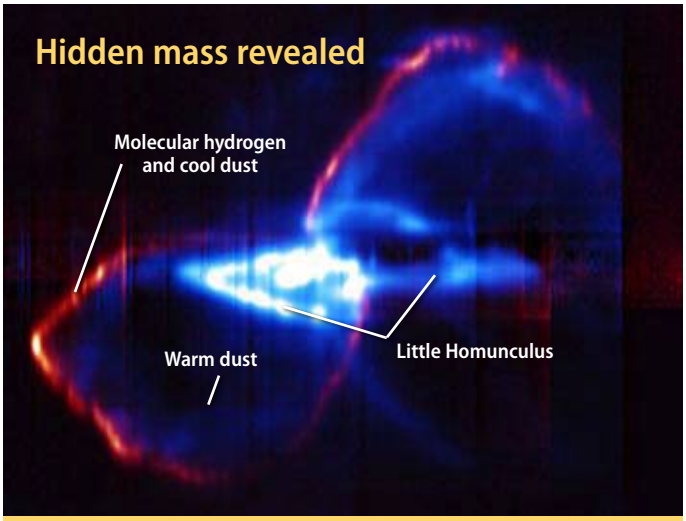
Matryoshka star

Eta Carinae is the stellar equivalent of a Russian matryoshka doll. The central star lies at the heart of nested layers of ejecta thrown off during the past few millennia. In 2003, using Hubble, a team led by Kazunori Ishibashi at the Massachusetts Institute of Technology discovered a small bipolar nebula — a miniature version of the Homunculus — within the Homunculus.

This Little Homunculus expands at about half the speed of the larger one and contains only a few tenths of a solar-mass of matter. Astronomers think the star ejected it during its 1890 eruption. Chesneau suggests the Little Homunculus and the butterfly nebula may be related, based on their similar sizes and orientations.

Some astronomers think looking out, not in, will best reveal Eta's secrets. Nathan Smith focuses on the circumstellar material because he thinks it holds the best clues for understanding the star's eruptive history. But outside the Homunculus, he admits, Eta Carinae "gets kind of messy."

The Homunculus lies within a larger nitrogen-rich shell that's at most a few thousand years old. This, in turn, sits within a 2-light-year-wide, X-ray-emitting shell discovered using NASA's Chandra X-ray Observatory. "And outside of that, we found another thin and filamentary shell that shows up in oxygen emission," Smith says. He calls this Eta's "oxygen veil"



GEMINI OBSERVATORY/NATHAN SMITH (UC BERKELEY)

THE HOMUNCULUS' 11-solar-mass molecular-hydrogen skin is red in this 2005 Gemini South Observatory spectrum. Eta Carinae shed this material in just 5 years during its Great Eruption. Dust also traces the Little Homunculus, ejected 50 years later.

NASA/JPL-CALTECH/NATHAN SMITH (UC BERKELEY)

A DEAD RINGER for the star that blew up as supernova 1987A is HD 168625, an 8th-magnitude LBV candidate about 7,200 light-years away in M17. Like the supernova remnant, this star hosts an unusual three-ringed nebula.

because it almost looks draped over the area. The star ejected this material as much as 10,000 years ago. The veil is already being reshaped by a neighboring star's outflow, so this is as far back as astronomers can trace Eta's behavior.

Supernova countdown?

Smith thinks the veil is a telling find: "We see a change from oxygen-bearing to very-nitrogen-rich debris, and that suggests different stages of nuclear burning." When a massive star fuses core hydrogen into helium, its energy comes from a set of reactions called the carbon-nitrogen-oxygen (CNO) cycle. As a side-effect of this process, the carbon and oxygen the star formed with are converted into nitrogen.

Because the Homunculus is unusually nitrogen and helium rich, astronomers think Eta Carinae is either near or past the end of its core-hydrogen-burning phase. But Smith wonders if the star may be further along in its evolution.

"Within a time span of a few thousand years, the star completely changed the chemical abundance of its ejecta," he explains. "It's the first time the ashes of nuclear burning were exposed. It happened very quickly compared to what we normally expect in stellar evolution."

Only after some instability exposed the star's deep, CNO-processed material would scientists have any reason to suspect Eta had completed its 3-million-year-long hydrogen cycle. Perhaps, Smith argues, the cores of Eta Carinae and other LBVs are more evolved than astronomers think.

When a star's core depletes its hydrogen, it reconfigures itself to fuse the helium ash that remains. This phase may last hundreds of thousands of years. When the core's helium becomes depleted, the star adjusts itself to fuse carbon. Models of stellar interiors show unstable periods characterize this phase, which lasts only about 1,000 years. Smith notes the energy of "burps and blasts" in model stars is oddly similar to Eta Carinae's Great Eruption. "The instability of LBVs may be like an early warning sign of the star's coming demise," he says.

Another clue that LBVs may be ripe for destruction lies in similarities between the nebulae they cast off and the unexpected three-ring nebula discovered around supernova 1987A. Astronomers identify the pre-explosion star as Sk –69°202, a blue supergiant in the Large Magellanic Cloud about 168,000 light-years away.

To explain the nebula's peculiar shape, astronomers invoke a complex sequence of events. As a red supergiant, Sk –69°202 merged with a companion star. This sped up its rotation and assisted in ejecting the nebula. Then, the star transitioned into a blue supergiant and exploded. But Smith says this scenario "requires that the nearest and best observed supernova in modern history just happens to also be a freak."

While the Spitzer Space Telescope can't target Eta Carinae, it can study other LBVs. Using Spitzer survey data, Smith found an ancient, ringed, bipolar nebula around HD 168625, an 8th-magnitude LBV candidate about 7,200 light-years away in the Omega Nebula (M17). With a surface temperature of 16,000 kelvins and a luminosity of about 100,000 Suns, the star is a near twin of Sk –69°202. And the ringed nebula, which Smith thinks the star ejected some 4,000 years ago, bears a close physical and chemical resemblance to 1987A's.

Growing evidence suggests at least some LBV stars blow up as type II supernovae in other galaxies, Smith says. He suggests Sk –69°202 was an unrecognized, low-luminosity LBV. If he's right, both HD 168625 and Eta Carinae could explode at any time. At their distances, they pose no threat to Earth, but their cataclysmic end would prove a dazzling sight for skywatchers — and a mother lode for astronomers.

"We don't understand Eta Carinae," cautions John Martin. "How do we know it isn't an oddball among oddballs?"

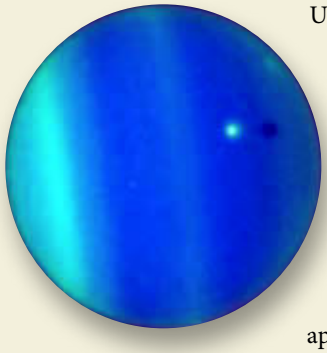
If Eta Carinae continues to brighten, enough ultraviolet radiation may escape to ionize gas in the Little Homunculus and surround the star with a compact emission nebula. But, just as likely, Eta could settle down for a decades-long quiet spell.

"Or maybe," Martin offers, "Eta will do something completely different that we aren't expecting." A

ONLINE EXTRA Astronomer John Martin discusses Eta Carinae's past, present, and future at www.astronomy.com/toc.

The first NEW

When William Herschel discovered Uranus in 1781 — the first planet found since antiquity — he opened a frontier astronomers are still exploring.



/// BY JULIE WAKEFIELD

Modern stargazers take it for granted that Uranus is the seventh planet from the Sun. But the people of ancient cultures weren't so enlightened. Nor were 16th- and 17th-century astronomers. For them, the solar system contained five planets besides Earth: Mercury, Venus, Mars, Jupiter, and Saturn, which anyone can easily see.

A mostly unknown amateur astronomer named Frederick William Herschel (1738–1822) changed our view of the solar system in 1781. Now, more than 225 years after his discovery of Uranus, the bluish-green giant continues to astound astronomers. Its mysterious weather, almost horizontal tilt, strange seasons, and alluring rings give scientists plenty to ponder.

As the planet moves to equinox in 2007, an event that happens once every 42 years, scientists are eagerly watching the heavens once again with hopes of finally gathering the data that will unlock many of the planet's lingering secrets. At equinox, amateur and professional astronomers alike will have an edge-on view of Uranus and its rings from Earth.

A history shrouded in mystery

Uranus possesses a long history of intrigue. The mysterious fleck befuddled Galileo Galilei (1564–1642). Among the first to point a telescope toward the heavens, the keen Italian observer likely spotted the faint pearl about a decade into the 17th century, but Galileo assumed it was a star, much as he had dismissed Neptune. Britain's first Royal Astronomer, John Flamsteed (1646–1719), appointed in 1675, the year the Greenwich Observatory debuted, saw the unidentified object in 1690. Flamsteed recorded it as "34 Tauri" in the constellation Taurus the Bull. A later Royal Astronomer, James Bradley (1673–1762), observed Uranus three times in the mid-18th century and dismissed it as well. And French astronomer Pierre Charles Le Monnier (1715–1799) sighted the celestial body a dozen times, with his last sighting in 1771, and never guessed it might be something other than a star.

A decade later, Herschel, who was largely unknown in England's scholarly circles, enlightened society's path to other worlds. In 1781, the astronomer identified the unusual object as a planet. For the first time, earthlings knew there was more to the solar system than what could be readily observed with unaided eyes. It was an international coup for a country that had just surrendered its American colonies.

Initially, even Herschel had thought the heavenly body was a comet. He first viewed it from the garden of his Georgian home in Bath, England, March 13, 1781,

▲ **A DARK SPOT on Uranus is the shadow of Ariel, seen here as a bright spot. Hubble snapped the images that comprise this composite July 26, 2006.** NASA/ESA/L. SROMOVSKY (UNIVERSITY OF WISCONSIN, MADISON)/H. HAMMEL (SPACE SCIENCE INSTITUTE)/K. RAGES (SETI)

WORLD

WILLIAM HERSCHEL expanded the solar system with his 1781 discovery that Uranus is a planet. This 18th-century astronomer and telescope-maker left a legacy of discovery that inspires modern-day astronomers.

IMAGES: NASA/JPL-CALTECH; HERSCHEL MUSEUM/ANDY BURNS

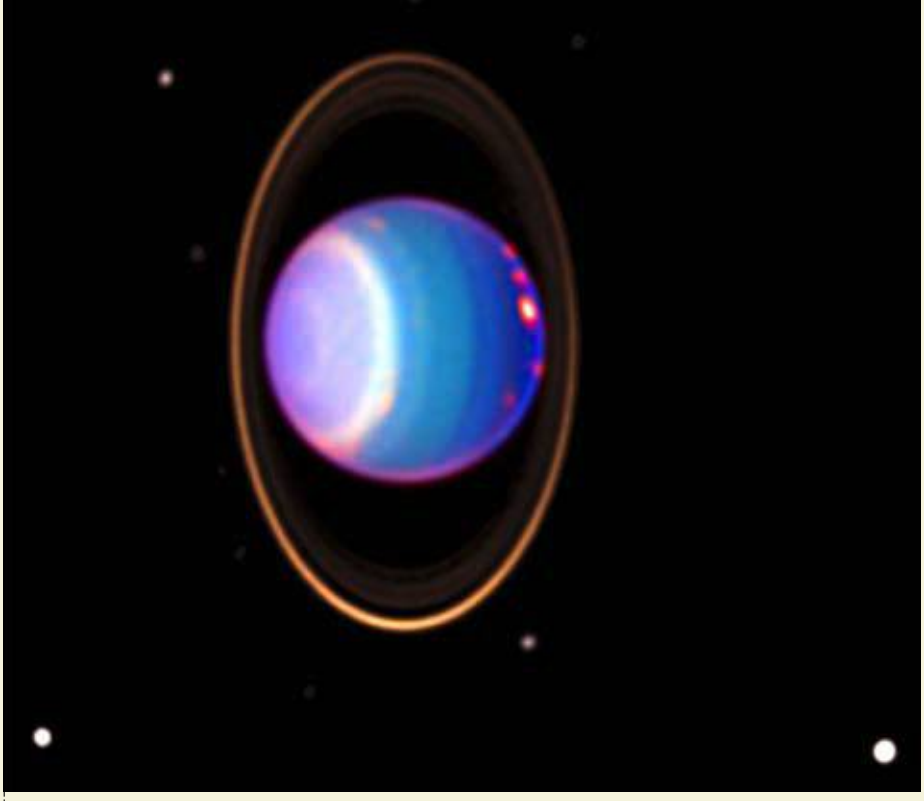
PHOTOMONTAGE: *ASTRONOMY*: KELLIE JAEGER

through a 7-foot-long (2m) telescope with a 6-inch-diameter (15 centimeters) reflecting mirror that he built himself. Within 4 days, he had verified its motion was not that of a comet.

The solar system doubles in size

Working from his home, Herschel observed the object whenever possible during the ensuing months, as did the entire astronomical community in Europe and elsewhere. By November 1781, the truth was obvious. The object moved in a relatively circular orbit, not the parabolic or elliptical orbits characteristic of comets, and its orbital path lay outside Saturn's — at least twice as far out. In this sense, Herschel's discovery more than doubled the size of the known solar system. The planet that would come to be known as Uranus orbits at an average distance of 1.78 billion miles (2.87 billion kilometers) from the Sun, tracing a path about 19 times farther from the Sun than Earth follows.

"You have to give credit to Herschel for acquiring such great experience at looking at these objects and being so systematic," says Heidi Hammel of the Space Science Institute in Ridgefield, Connecticut. "Although there were discussions theoretically about other unknown worlds going around the Sun, this was the first concrete evidence. It really opened up the study of the heavens by proving, physically, there were things out there to be discovered."



ERICH KARKOSCHKA (UNIVERSITY OF ARIZONA)/NASA

BRIGHT CLOUDS appear as reddish ovals on Uranus' surface, while several moons lie outside the planet's yellowish rings. The Hubble Space Telescope's Near-Infrared Camera and Multi-Image Spectrometer acquired this false-color image.

A man of many talents

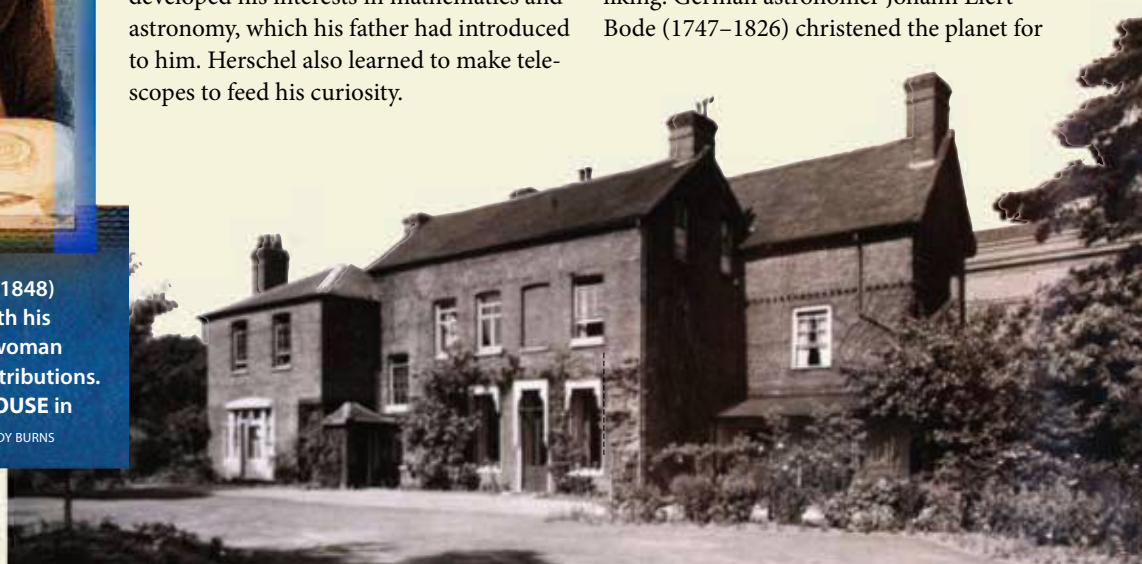
Astronomy was actually a second career for the German-born Herschel. As teenagers, Herschel and his brother were sent in 1755 to England when the crowns of England and Hanover were united under George II. There, Herschel was an oboist in the Hanoverian Guards. He stayed on after his service, quickly mastering English and changing the spelling of his name from Friedrich Wilhelm to Frederick William. His music career flourished in England; a band director, he composed 26 symphonies and various shorter works. On the side, he developed his interests in mathematics and astronomy, which his father had introduced to him. Herschel also learned to make telescopes to feed his curiosity.

In 1772, his sister Caroline (1750–1848) joined him in Bath and assisted with his observations. Caroline was absent when he sighted Uranus, the night that brought him fame, but she made contributions of her own to astronomy. Caroline learned to grind and polish telescope mirrors, observed and cataloged nebulae, and was the first woman recognized for her scientific contributions. She received a pension from King George III to further her astronomical studies.

Herschel originally named his find "the Georgium Sidus" to honor his patron, the king of England. The French, however, called the planet "Herschel" for a time, although the moniker was not to Herschel's liking. German astronomer Johann Elert Bode (1747–1826) christened the planet for

HERSCHEL MUSEUM/ANDY BURNS

▲ CAROLINE HERSCHEL (1750–1848) assisted her brother, William, with his observations. She was the first woman recognized for her scientific contributions.



▶ HERSCHEL OBSERVATORY HOUSE in Slough, England. HERSCHEL MUSEUM/ANDY BURNS

the mythical Greek god "Ouranos," who personifies the heavens. After much debate over other names, the third appellation, Uranus, came into common usage everywhere by the middle of the 19th century.

Although the "Georgium" moniker proved unpopular outside England, Herschel's homage probably helped garner him an annual stipend from George III to fund his astronomical work. The grant was about two-thirds of his salary as Court Astronomer.

Herschel built more than 400 telescopes, the largest of which was 40 feet (12m) long. He discovered a new moon of Saturn the first night he tested it in 1789, but the scope's 49.5-inch-wide (1.25m) mirror proved impractical. Herschel made most of his later discoveries with smaller telescopes, including his sighting of Uranus' two largest moons, Titania and Oberon. Herschel's son John, who would also become a famous astronomer, gave these moons their Shakespearean names years after his father's death. Titania and Oberon are the rulers of the fairies from *A Midsummer Night's Dream*.

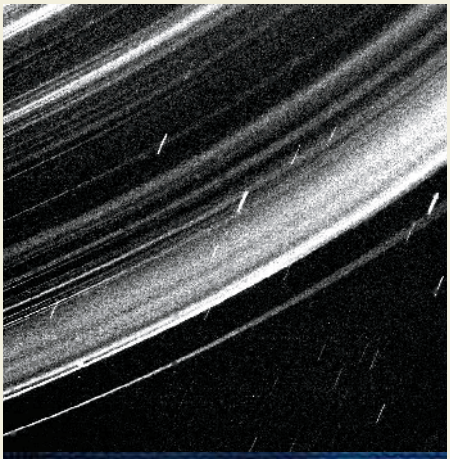
Today, visitors still can be inspired at Sir William Herschel's home on Bath's King Street, where he first sighted Uranus, or at London's Science Museum, which houses his "Uranus telescope."

In addition to his discoveries of Uranus and some of its satellites and his exploration of infrared radiation, Herschel was the first to demonstrate that the solar system itself moves through space. Reflecting the sentiments of his era, Herschel thought it possible that beings inhabited every planet in the solar system, including the Sun. He speculated that the Sun's surface was cool and protected by a thick cloud layer from its hot atmosphere, which enabled life there. In his writings, however, he never specified what Uranians or such Sunlings might be like.

Modern discoveries

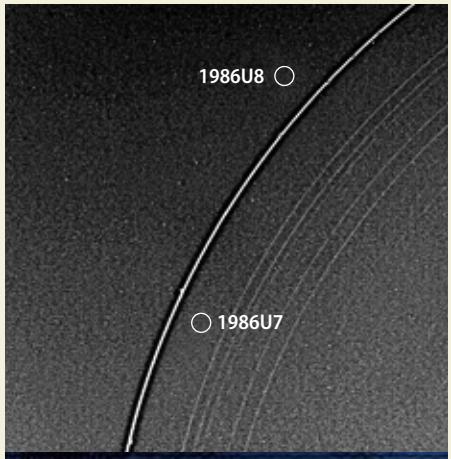
Little would be learned about the puzzling planet for nearly 200 years after its discovery. Yet, even Herschel probably never envisioned that astronomers would eventually count 12 rings and 27 moons around the planet; those discoveries would also be named in the Shakespearean tradition.

Julie Wakefield *is a Washington-based science writer and author of* Halley's Quest *(J. Henry Press, 2005), a biography of Edmond Halley.*



NASA/JPL-CALTECH

URANUS' RINGS resemble Saturn's. Scientists aboard the Kuiper Airborne Observatory observed these rings in 1977, while a ground-based team simultaneously watched from Perth Observatory in Australia.



NASA/JPL-CALTECH

SHEPHERD MOONS 1986U7 and 1986U8 (circled) lie on either side of Uranus' bright outer epsilon ring. The moons keep the ring's material from spreading out. Voyager 2 captured this image January 21, 1986.

In the intervening years, the planet's perplexing orbit around the Sun, which takes 84 Earth years to complete, seemingly defied Newton's laws. Sixty-five years would pass before astronomers understood the planet's wayward motion. In September 1846, they confirmed the existence of an even larger gaseous planet — Neptune, a billion miles farther out — that influences the shape of Uranus' orbit.

This year, astronomers hope to advance understanding of the blue-green giant when Uranus reaches equinox December 7. The phenomenon happens once every 42 years — twice each orbit. At equinox, Earth-based observers will have an edge-on view of Uranus and its rings. When the rings "close up" in this fashion, astronomers will be better able to view the fainter rings.

Perhaps more rings and moons will be discovered. Astronomers' capabilities were limited when the last equinox occurred, in 1965. "We didn't have any of the modern telescopes, electronic cameras, and modern instruments," Hammel explains. "There weren't laptop computers on every astronomer's desk."

A ring thing

While at Bath, Herschel, who was knighted in 1816, reported seeing a ring around Uranus but realized his error. Although his sighting was clearly a mistake, serendipity intervened in March 1977, when a 10-person team led by MIT's James Elliot discovered nine faint rings encircle Uranus. The scientists used the Kuiper Airborne Observatory — a jet aircraft decked out with a large telescope — to monitor the planet's eclipse of a star. But they observed a series of unexpected brightness dips immediately before and after Uranus blocked the star. Before the jet touched down again, the team contemplated the existence of a ring system, which data analysis soon confirmed.

Elliot maintains this revelation opened up the whole field of ring study. "Saturn was no longer the only planet known to have rings." Galileo, one of the first astronomers to observe the night sky with a telescope, discovered Saturn's rings in 1610. Since the Elliot team's find, astronomers have discovered rings around all the jovian planets. Voyager 2 wouldn't detect the uranian ring system directly until the craft flew by the planet in 1986. At that time, Voyager 2's cameras also captured images of two new rings: 10th ring 1986 U1R; and a single image of 11th inner ring 1986 U2R.

In 2004, at Keck Observatory in Hawaii, a team headed by Imke de Pater, an astronomer at the University of California at Berkeley and ring expert, confirmed the existence of this inner 11th ring. The astronomers used Keck's second-generation Near Infrared Camera to make the confirmation. The telescope's adaptive-optics system reduces atmospheric blurring. This enhancement, combined with the fact that the rings were seen nearly edge-on, enabled

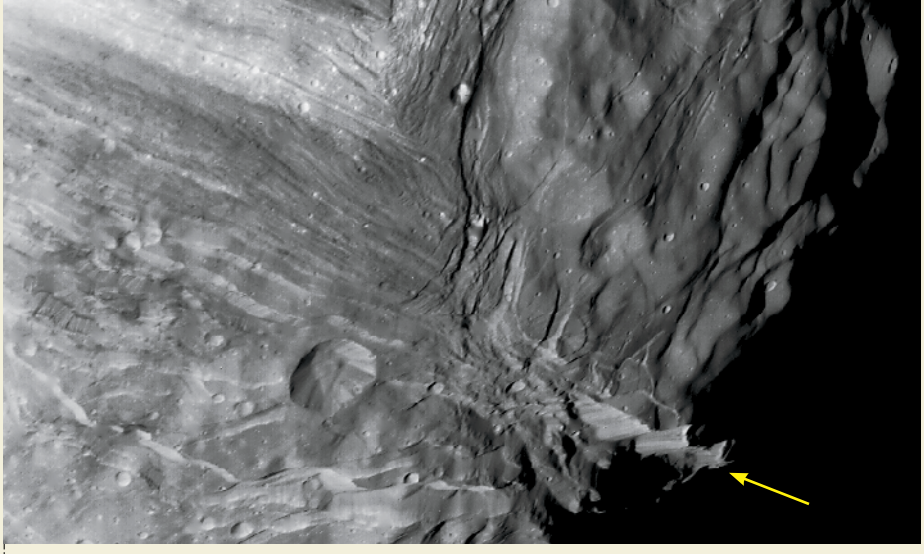
the team to capture this layer of rocky fragments. They calculated the ring, the planet's faintest, to be 2,175 miles wide (3,500 km) and nearly 25,000 miles (40,000 km) from the core of this gaseous planet. That is only 9,000 miles (14,000 km) from the top of the atmosphere. This ring comprises mainly hydrogen and helium. The epsilon ring, outermost of the innermost set of nine rings, is about 1,000 times brighter.

The Space Science Institute's Hammel and Berkeley's de Pater and others have observed Uranus since the beginning of the millennium with the Keck II telescope's adaptive optics. Ironically, Herschel's discovery in 1800 of infrared radiation laid the foundation for much of this modern capability.

In December 2005, NASA's Hubble Space Telescope imaged two more rings, bringing the total to 13. Astronomer Mark Showalter of NASA's Ames Research Center in Mountain View, California, and his team characterized the additional rings as a second ring system because they are significantly farther from the planet than the original ring system. They also found two new moons, Mab and Cupid, numbers 26 and 27.

Further data analysis revealed the outermost ring is blue, much like Saturn's outer ring, according to de Pater. "The blue color indicates the ring is mainly comprised of submicron-size particles."

Astronomers attribute the blue color of Uranus' outer ring to the associated moon, Mab. This object's subtle gravitational pull recaptures the larger particles but allows the smaller ones — which are 1/1,000 the width of a human hair — to remain in orbit around the planet. "Embedded moons appear to exert forces governing particle distribution," de Pater explains. Some scientists had speculated Saturn's outer ring's blue color might be due to plumes on its embedded moon's surface. "But Mab is too small to be internally active," de Pater says. The blue ring is not visible in the near-infrared, only in the visible spectrum.



NASA/JPL-CALTECH

MIRANDA LIES CLOSEST to Uranus of the planet's five largest satellites. This 150-mile-wide (250 km) Voyager 2 image shows a large impact crater spanning 15 miles (25 km), and an enormous, 12-mile-high (20 km) fault scarp (arrow).

In contrast, the 12th ring appears reddish, like the majority of rings around Jupiter, Saturn, Neptune, and Uranus. The rings appear red because the larger particles, ranging in diameter from many microns to meters, scatter and reflect mainly red light. Typically, the particles are older and have been heavily bombarded by other debris.

Channeling the weather

Uranus' weather is changing in surprising ways. The Voyager 2 spacecraft spied a total of 10 clouds above the entire planet in 1986. The images led many scientists to believe its atmosphere is static. In fact, some theorized Uranus' atmosphere is so stratified that it suppresses any movement of the large air masses required to create clouds.

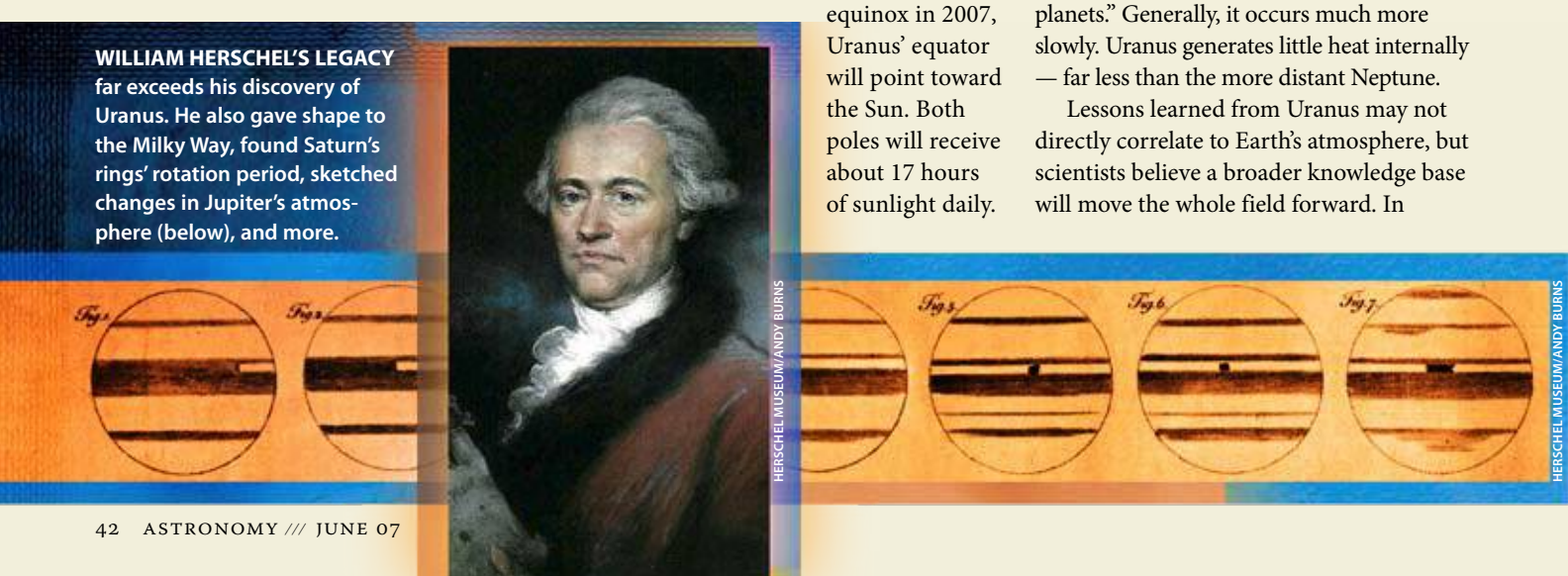
When Voyager passed by 20 years ago, the planet's south pole was pointed at the Sun, and the north pole lay in darkness. At equinox in 2007, Uranus' equator will point toward the Sun. Both poles will receive about 17 hours of sunlight daily. For a time, both of the planet's hemispheres will be symmetrically illuminated during Uranus' 17-hour day.

In recent years, as the end of summer in the planet's southern hemisphere has drawn near, images from Keck II and Hubble revealed massive cloud systems, 6,500 miles (2,000 meters) in diameter, which existing models did not predict. The planet appears to be exhibiting a much greater sensitivity to sunlight than expected. "A very minute change in sunlight" is causing a change in heat balance in the atmosphere, Hammel explains.

As it is, the amount of sunlight reaching Uranus is 1/400 the intensity of Earth's sunlight. "This [sensitivity] suggests a gap in our knowledge in how atmospheres in general respond to changes," Hammel says. On Uranus, changes in radiation may be "turning on" convection or "turning off" processes that had inhibited cloud formation. MIT's Elliot concurs: "We still don't understand the basic energetics of the planet. Solar heating occurs differently on Uranus than most planets." Generally, it occurs much more slowly. Uranus generates little heat internally — far less than the more distant Neptune.

Lessons learned from Uranus may not directly correlate to Earth's atmosphere, but scientists believe a broader knowledge base will move the whole field forward. In

WILLIAM HERSCHEL'S LEGACY far exceeds his discovery of Uranus. He also gave shape to the Milky Way, found Saturn's rings' rotation period, sketched changes in Jupiter's atmosphere (below), and more.



HERSCHEL MUSEUM/ANDY BURNS

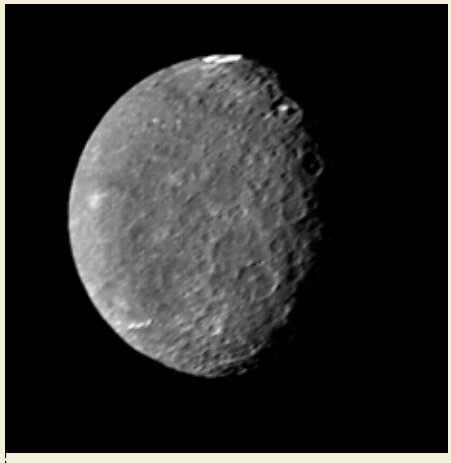
HERSCHEL MUSEUM/ANDY BURNS

NASA/JPL-CALTECH

MIRANDA'S bright and heavily cratered surface shows a mix of grooves, cliffs, and valleys. This strange moon comprises equal parts of water-ice and rocky material.

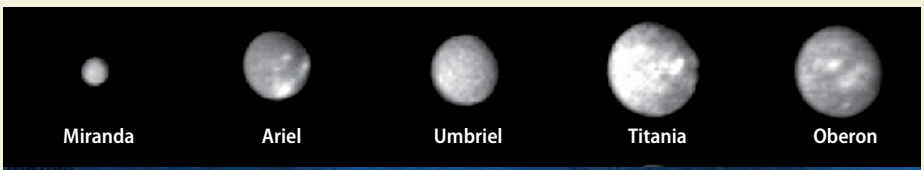
NASA/JPL-CALTECH

ARIEL shows extensive faults, scarps, and cratering over its 750-mile (1,200 km) diameter. Many of the satellite's craters are 3 to 6 miles (5 to 10 km) across.



NASA/JPL-CALTECH

UMBRIEL is the darkest of Uranus' five largest moons. Little geological activity, low reflectivity, and heavy cratering are the main features in this Voyager 2 image.



NASA/JPL-CALTECH

FIVE LARGE MOONS and 12 smaller satellites circle Uranus. Voyager 2 returned these images January 20, 1986. Oberon and Titania are about half the Moon's size, while Miranda is about one-quarter of their size. The spacecraft captured the images from distances of 3.1 million to 3.8 million miles (5 million to 6.1 million kilometers) from Uranus.

NASA/JPL-CALTECH

TITANIA'S bright spots are likely small craters surrounded by ejected material. Linear troughs (right) may be fault canyons. Such features suggest this moon has an active interior.

NASA/JPL-CALTECH

OBERON, the outermost of Uranus' largest satellites, shows a large impact crater at its center with a bright central peak and dark spots of carbon-rich material on its floor.

another 21 years, Uranus' south pole will be in darkness, and its north pole will bathe in the Sun's distant rays. By then, astronomers may have explanations for the puzzling changes now being witnessed.

Full tilt

Uranus' strange tilt still fascinates astronomers. An outlier in our solar system, the planet tilts at 98°, spinning almost horizontally. The other planets, in contrast, spin almost vertically with respect to their orbital planes. Uranus' tilt likely also causes extreme seasonal variations in its weather.

The mystery of why Uranus careens through space at a 98° angle remains unsolved. Until recently, the reigning wisdom held that a large collision during its formation tipped the planet onto its side. But a new theory, proposed by Argentine astronomer Adrian Brunini and his colleagues at the Facultad de Ciencias Astronomics y Geofisicas in Buenos Aires, suggests a series of smaller shifts might have caused Uranus' unusual axial orientation. These shifts could have come about as the giant planets were interacting with one another during the earliest stages of the formation of our solar system, according to their paper published in *Nature* in April 2006.

Most likely, the shifts occurred billions of years ago, when the planets were closer to the Sun and to one another, Brunini explains. The "gravitational dance" that ensued could have changed their axial tilts without requiring a massive impact with an Earth-sized object, as scientists have long believed.

Reconstructing events that occurred billions of years ago and billions of miles away is a daunting task. To solve this enigma, astronomers need to further study Brunini's new theory. "I honestly don't know what observational data could prove it one way or the other," Hammel says. "But this is the nature of science."

Herschel might not have been right about everything, but he piqued humankind's imagination about other worlds, a legacy that stands to this day. Undoubtedly, if Sir William were around today, he would be excited about the viewing opportunities the arrival of Uranus' equinox brings for astronomers.

ONLINE EXTRA Learn more about the Herschel family dynasty online at www.astronomy.com/toc.

BY MARTIN RATCLIFFE AND ALISTER LING

JUNE 07

Venus and Jupiter rule the evenings

The month opens with the best views of Mercury and Venus for 2007, with both planets high in the evening sky. Jupiter, the solar system's giant, reaches its best views, too, and lights the sky nearly all night. ☾ Saturn puts on its last display before it becomes lost in the Sun's glare, but the ringed planet will return later in the year. All in all, this adds up to a great month for planetary observers.

44 Three planets glow at dusk
49 Watch for a Boötid outburst
49 See the Moon's Humboldt Crater
50 Follow Encke's southern dive
50 When to view the planets
50 Track Jupiter's satellites
51 Observe Vesta

Visible to the naked eye
Visible with binoculars
Visible with a telescope

THE TWIN CRESCENTS of the Moon and Venus remind us of our place in space. This daylight view shows the Moon before it occulted Venus in May 2004. A similar event, visible from North America and Europe, occurs June 18. IVÁN ÉDER

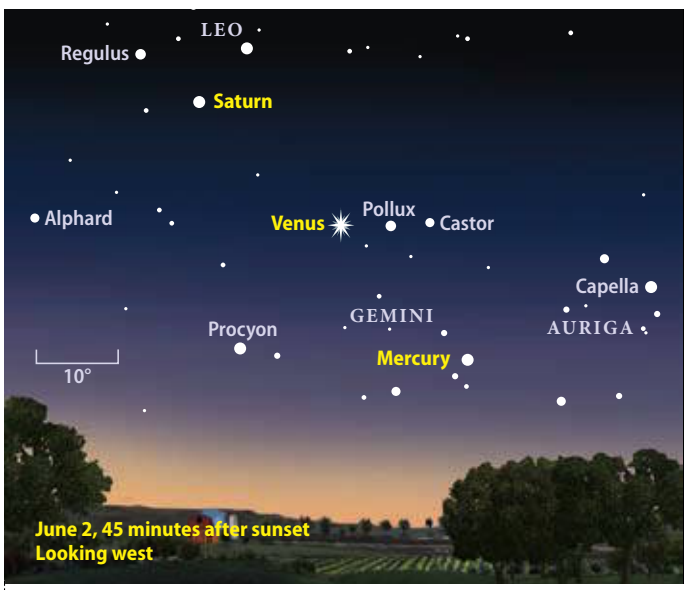
Venus pops out of the evening twilight as the first planet to become visible after sunset. **Mercury** soon follows, although it's visible at a much lower altitude than its brighter neighbor. On June 1, Mercury stands 10° above the west-northwestern horizon 45 minutes after sunset and remains visible until after 10 P.M. local time for those with clear, flat, western horizons. Glowing at magnitude 0.5, it outshines both Castor and Pollux, the two brightest stars in Gemini the Twins. Mercury forms a triangle with the two stars Eta (η) and Mu (μ) Geminorum, which represent one of the twins' feet.

Mercury reaches greatest eastern elongation — its maximum angle east of the Sun — as the month opens. On June 2, the planet is 23.4° from our star.

By June 10, when Mercury moves into central Gemini, the planet remains 7° high by 9:35 P.M. local time. Its brightness, though, will have faded by a whole magnitude, which makes it comparable to Castor and more difficult to spot.

A small scope reveals Mercury to be a 37-percent crescent June 1. Watch the illuminated fraction of the disk diminish as Mercury's orbit carries the innermost planet closer to Earth. By June 10, Mercury slims to a lean 20-percent crescent. During the same period,

— *continued on page 49*



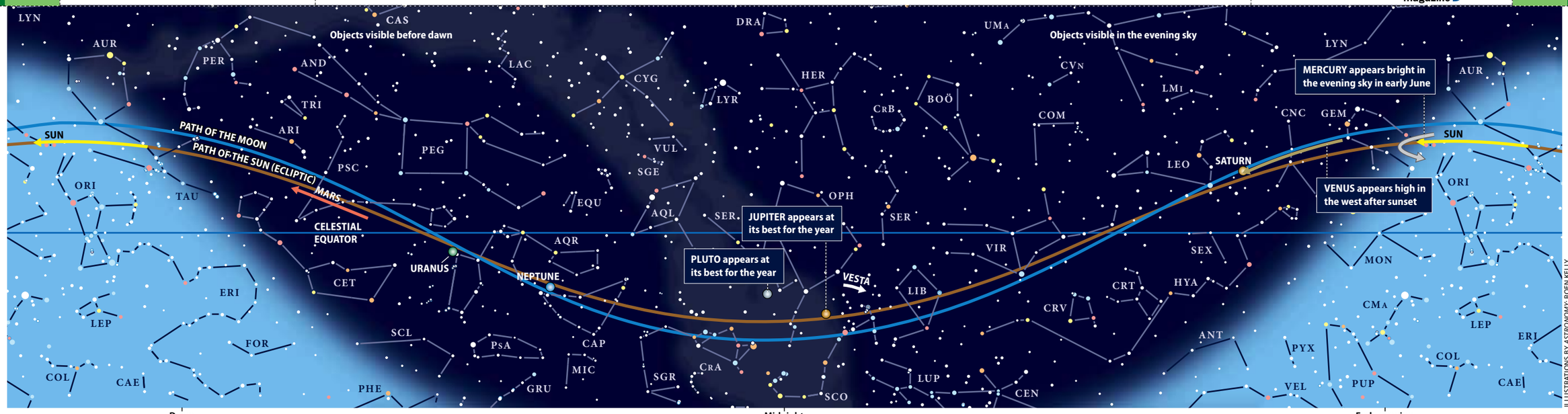
ASTRONOMY: THEO COBB

MERCURY, VENUS, AND SATURN form a planetary parade in evening twilight. Jupiter, rising in the east, joins them after June 5.

Planets this month

This map unfolds the entire night sky from sunset (at right) until sunrise (at left). Arrows and colored dots show motions and locations of solar system objects during the month.

Astronomy magazine



Dawn — Midnight — Early evening

[16] [15] [14] [13] [12] [11] [10] [09] [08] [07] [06] [05] [04] [03] [02] [01]

[30] [29] [28] [27] [26] [25] [24] [23] [22] [21] [20] [19] [18] [17] [16] [15] [14]

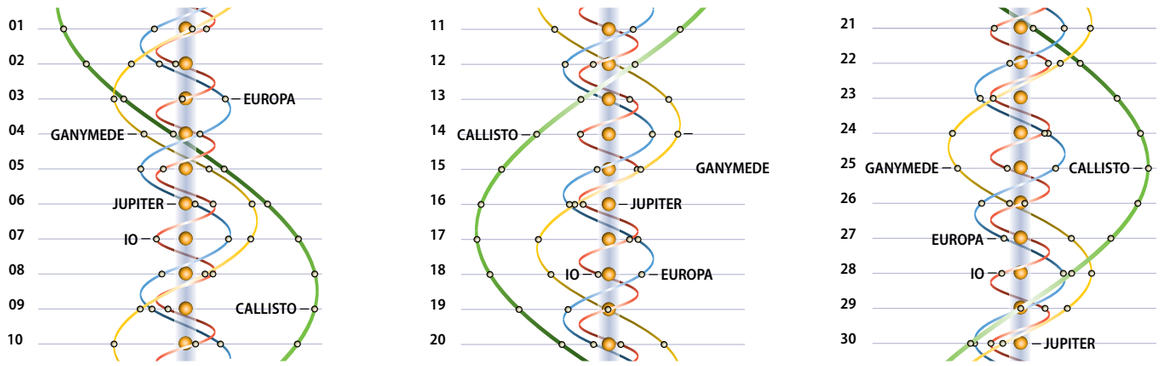
To locate the Moon in the sky, draw a line from the phase shown for the day straight up to the curved blue line.

ILLUSTRATIONS BY *ASTRONOMY*: ROEN KELLY

PLANETS	MERCURY	MERCURY	VENUS	VENUS	MARS	JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
Date	June 1	June 15	June 1	June 30	June 15	June 15	June 15	June 15	June 15	June 15
Magnitude	0.3	2.1	−4.4	−4.6	0.8	−2.6	0.5	5.8	7.9	13.9
Angular size	7.9"	10.7"	21.5"	30.8"	6.0"	45.7"	17.1"	3.5"	2.3"	0.1"
Illumination	40%	13%	54%	36%	88%	100%	100%	100%	100%	100%
Distance (AU) from Earth	0.850	0.630	0.775	0.542	1.556	4.313	9.726	19.979	29.502	30.293
Distance (AU) from Sun	0.409	0.460	0.722	0.725	1.382	5.316	9.216	20.091	30.047	31.299
Right ascension (2000.0)	6h14.5m	6h49.5m	7h50.5m	9h35.0m	1h26.1m	16h49.5m	9h34.0m	23h19.1m	21h37.1m	17h50.2m
Declination (2000.0)	25°16'	22°03'	23°41'	15°11'	7°25'	−21°46'	15°48'	−5°14'	−14°29'	−16°23'

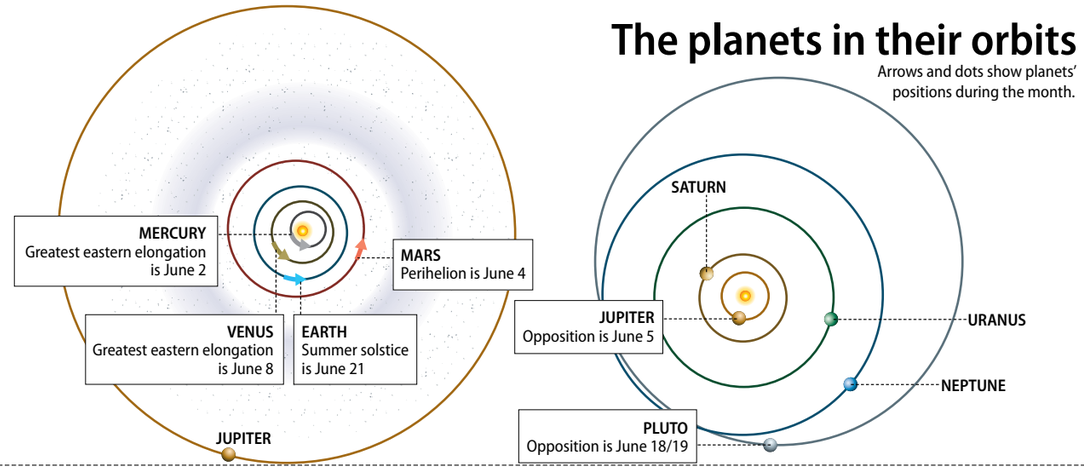
Jupiter's moons

Dots display positions of Galilean satellites at 11 P.M. EDT on date shown. South is at top to match the view through a telescope.



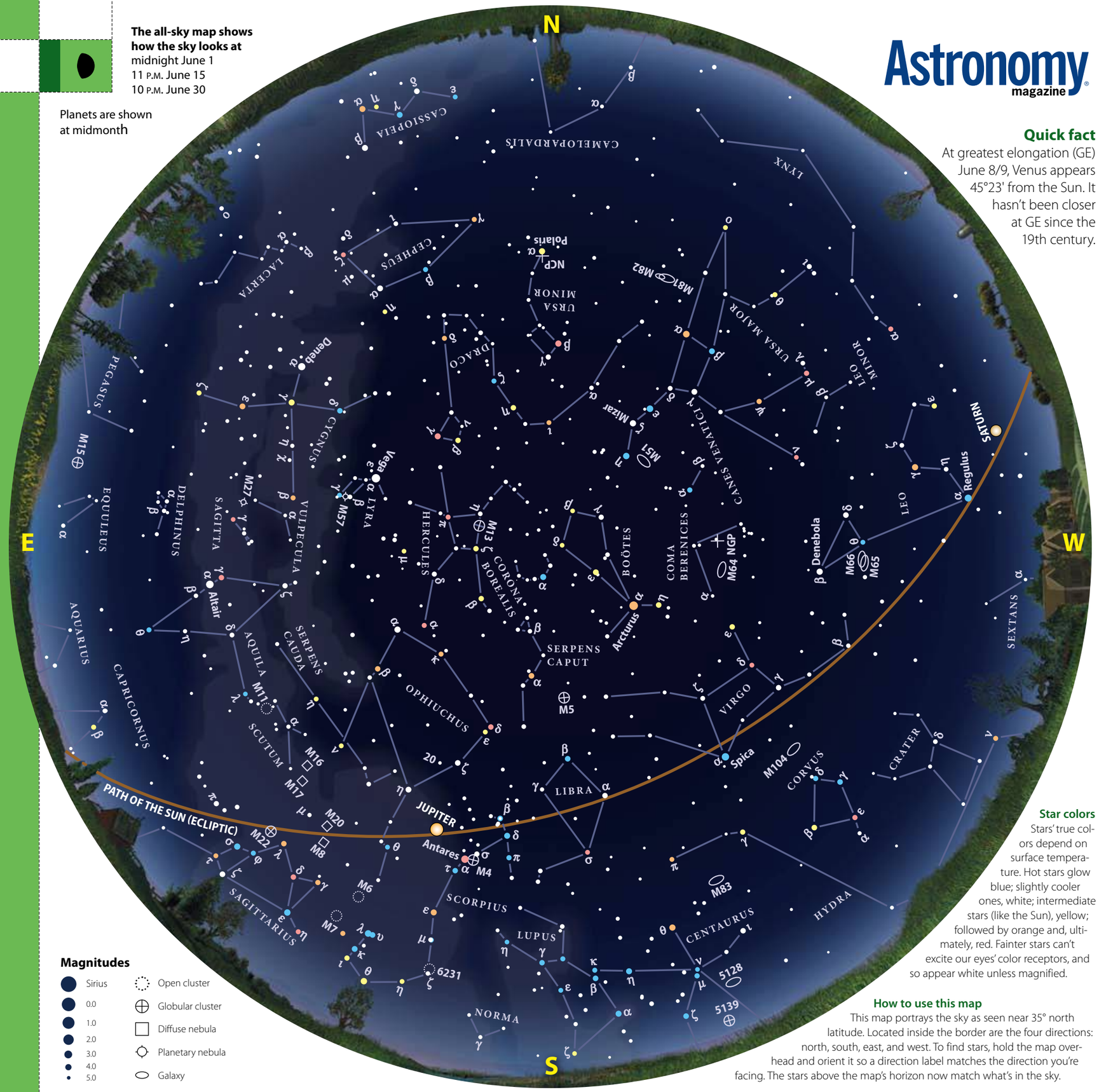
The planets in their orbits

Arrows and dots show planets' positions during the month.



The all-sky map shows how the sky looks at
midnight June 1
11 P.M. June 15
10 P.M. June 30

Planets are shown at midmonth



Magnitudes

- Sirius
- 0.0
- 1.0
- 2.0
- 3.0
- 4.0
- 5.0
- Open cluster
- Globular cluster
- Diffuse nebula
- Planetary nebula
- Galaxy

Star colors
Stars' true colors depend on surface temperature. Hot stars glow blue; slightly cooler ones, white; intermediate stars (like the Sun), yellow; followed by orange and, ultimately, red. Fainter stars can't excite our eyes' color receptors, and so appear white unless magnified.

How to use this map
This map portrays the sky as seen near 35° north latitude. Located inside the border are the four directions: north, south, east, and west. To find stars, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.

Astronomy magazine

Quick fact
At greatest elongation (GE) June 8/9, Venus appears 45°23' from the Sun. It hasn't been closer at GE since the 19th century.

june 07

SUN.	MON.	TUES.	WED.	THURS.	FRI.	SAT.
					[01]	[02]
[03]	[04]	[05]	[06]	[07]	[08]	[09]
[10]	[11]	[12]	[13]	[14]	[15]	[16]
[17]	[18]	[19]	[20]	[21]	[22]	[23]
[24]	[25]	[26]	[27]	[28]	[29]	[30]

ILLUSTRATIONS BY *ASTRONOMY*: ROEN KELLY

01 The Moon passes 6° south of Jupiter, 8 A.M. EDT

02 Mercury is at greatest eastern elongation (23°), 6 A.M. EDT

04 Mars is at perihelion (128.4 million miles from the Sun), 9 A.M. EDT

05 Jupiter is at opposition, 7 P.M. EDT

08 Last Quarter Moon occurs at 7:43 A.M. EDT

Venus is at greatest eastern elongation (45°), 11 P.M. EDT

10 The Moon passes 5° north of Mars, 6 P.M. EDT

12 The Moon is at perigee (226,042 miles from Earth), 1:07 P.M. EDT

14 New Moon occurs at 11:13 P.M. EDT

18 The Moon passes 0.6° north of Venus, 11 A.M. EDT

19 Pluto is at opposition, 3 A.M. EDT

The Moon passes 0.4° north of Saturn, 4 A.M. EDT

The Moon passes 0.4° north of Regulus, 8 P.M. EDT

21 Summer solstice occurs at 2:06 P.M. EDT

22 First Quarter Moon occurs at 9:15 A.M. EDT

24 The Moon is at apogee (251,370 miles from Earth), 10:25 A.M. EDT

28 The Moon passes 0.5° south of Antares, 4 A.M. EDT

The Moon passes 6° south of Jupiter, 10 A.M. EDT

Mercury is in inferior conjunction, 3 P.M. EDT

30 Full Moon occurs at 9:49 A.M. EDT

ONLINE EXTRA For definitions of terms, visit www.astronomy.com/glossary.

— *continued from page 44*

the planet's tiny disk grows from 8" to 10".

Venus, high above Mercury, begins June in line with Gemini's Castor and Pollux. By June 12, the planet lies in the same low-power field of view as the Beehive open star cluster (M44) in Cancer the Crab.

Venus displays a larger disk than Mercury in part because it has greater physical size. Venus' diameter is comparable to Earth's, whereas Mercury is closer to our Moon's size. But it's also true that Venus lies much closer to Earth, and this only exaggerates the disparity between the two inner planets.

On June 1, Venus spans 22", and a telescope shows a half-moon phase. Venus reaches its greatest eastern elongation June 9, when it lies 45.4° from the Sun. But observers frequently report the exact moment of half phase, which astronomers call dichotomy, a few days earlier. This phenomenon is called the Schröter effect, after Johann Schröter, who in 1793 first noted that, on the predicted day of dichotomy, Venus' terminator already looks concave. Can you see this effect June 9?

Throughout the rest of the month, Venus' illuminated fraction shrinks further as the planet moves toward its conjunction with Saturn. On June 17, a crescent Moon lies 7° west of Venus, while Saturn stands 9° to its east. On the next evening, the Moon nestles beautifully between the two planets. This is a fine opportunity for some wide-angle astrophotography.

Martin Ratcliffe *is the former president of the International Planetarium Society.* **Alister Ling** *is a meteorologist for Environment Canada.*

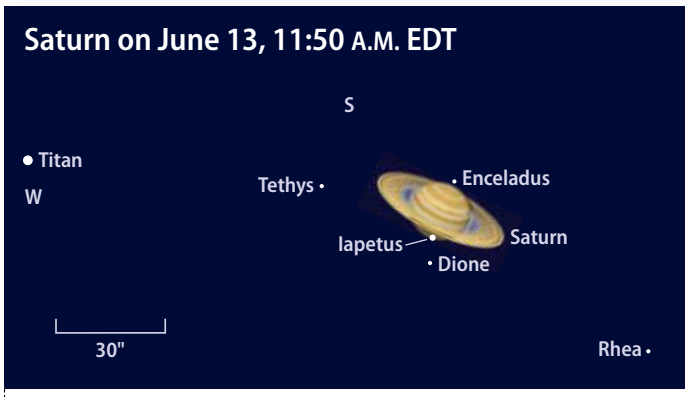
On June 18, a 3.6-day-old waxing crescent Moon will occult Venus for North American and European observers. The event occurs between 9 and 10 A.M. EDT. In North America, the event is visible from locations northeast of a line from the Great Lakes to the Carolinas. For information for your locale, visit www.lunar-occultations.com.

On June 30, Venus and **Saturn** meet in Leo. Just 41' separate the two planets, which are close enough to be visible together in the same low-power field. Venus' disk is now 31" across and 35-percent illuminated. The slender crescent contrasts with Saturn's small but full disk, which spans 17". But include Saturn's ring system, and its size appears comparable to Venus'.

LOOK OUT FOR A BOÖTID OUTBURST

June offers no major meteor showers. Three minor showers provide an occasional meteor, but it will be difficult to separate these fiery streaks from the usual sporadic meteors, about 7 of which appear each hour every night. The Arietids peak June 7, but the shower is normally seen only with radar and radio. In any case, a bright Moon squelches any visual meteors.

The Moon also dims prospects for the Boötids, expected to peak June 27. In 1998 and 2004, observers recorded substantial rates (above 20–50 per hour). Both of these outbursts were related to returns of Comet 7P/Pons-Winnecke, the source of the shower's particles. Despite the Moon, keep watch a few days before the expected peak for any unusual activity.



CATCH IAPETUS as it grazes Saturn's northern limb June 13. Titan, the brightest saturnian moon, lies far to the west. *ASTRONOMY:* THEO COBB

HUMBOLDT'S GOOD LIBRATION

This challenging lunar crater lies near the Moon's southeastern limb. It's visible only when conditions are just right. From June 16 to 21, when sunlight illuminates the lunar limb during a favorable libration, you can add Humboldt to your list of lunar targets to explore.

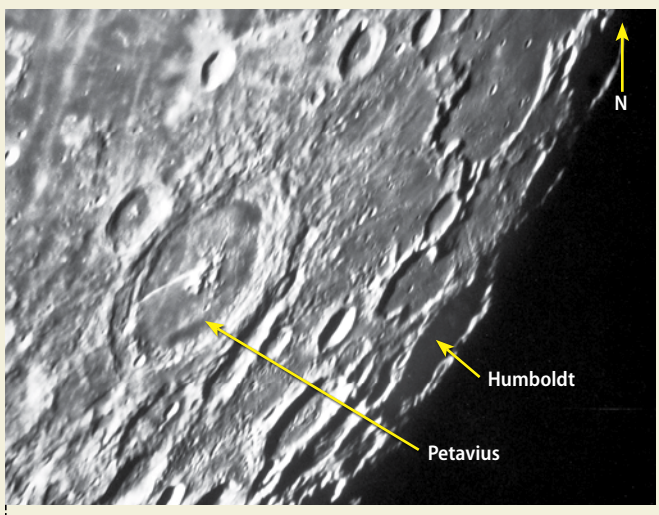
Librations are changes in the angle the Moon presents to observers. In June, our satellite's southeastern limb tilts toward Earth a bit more than usual. This extra tilt lets observers see southeastern features located a few degrees beyond the Moon's typical limb.

To find Humboldt, use the prominent crater Petavius as a guide. You'll find Patavius beyond the southern end of Mare Fecunditatis.

Of the pair, Petavius is better known. But Humboldt, with a diameter of 333 miles, is 29-percent larger.

Fractures rack the floors of Humboldt and Petavius. The fractures formed when volcanic activity cracked the surface.

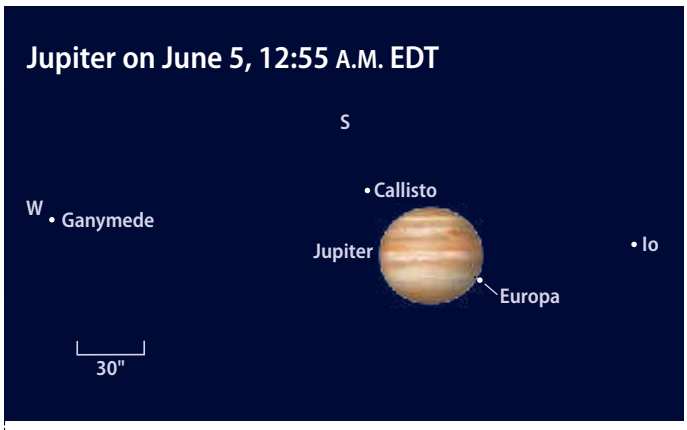
Mid-June offers a rare chance to see Humboldt's floor and central mountain complex. Begin observing as soon as the new crescent is visible after New Moon June 15.



LOOK FOR HUMBOLDT CRATER on the young Moon after mid-month. Favorable lightning and lunar tilt will allow observers to study the crater's fractured floor.

/// WHEN TO VIEW THE PLANETS

EVENING SKY	MIDNIGHT	MORNING SKY
Mercury (west)	Jupiter (south)	Mars (southeast)
Venus (west)	Saturn (west)	Jupiter (west)
Jupiter (southeast)		
Saturn (southwest)		



EUROPA AND ITS SHADOW transit Jupiter's cloudy disk June 5, the same day the giant planet reaches opposition. *ASTRONOMY:* THEO COBB

Saturn will slip into twilight by August, so this month is really its last hurrah. The planet shines at magnitude 0.6. The rings are narrowing from our point of view. Saturn is moving along its orbit to a location where the rings will appear edge-on to us in 2009. This month, they show a 14° tilt.

You'll find Saturn in the gap between Venus and Regulus, Leo's brightest star. By the end of June, just 7° separate Saturn from the star. Swing your scope to study Saturn's rings, and try to spot the rings' shadows on the planet's eastern side.

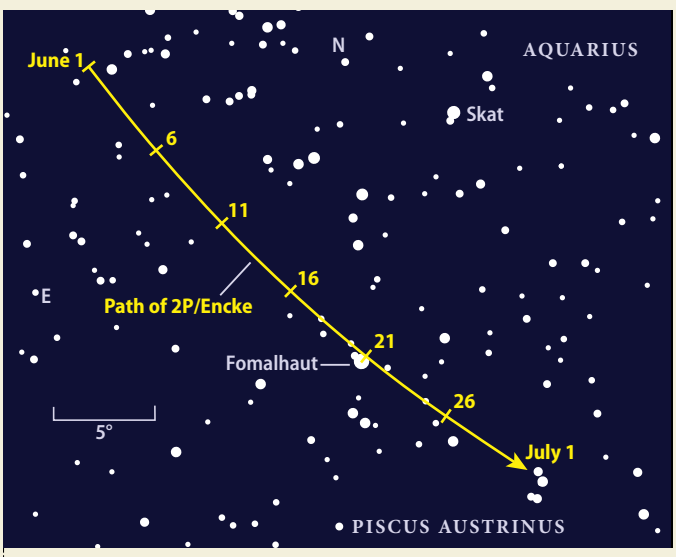
Titan, Saturn's major moon, shines at magnitude 8.4 and circles Saturn almost twice per month. You can see it north of Saturn on June 11/12 and June 27/28 and south of Saturn on June 3/4 and June 19/20.

The orbit of the two-toned outer moon Iapetus now crosses the planet's face. In the next couple of years, we'll see the inner moons actually transiting the planet as Saturn's rings tip edgewise.

On June 13, you can spot Iapetus transiting Saturn's north pole, moving from the eastern side of the planet to the western. Once Iapetus reaches its western elongation in early July, it'll shine at its brightest (magnitude 10.2). The fainter moons become more difficult to spot as Saturn sinks lower into twilight and our atmosphere's haze.

As Venus and Saturn sink lower in the western sky, **Jupiter** rises in Ophiuchus. On June 1, it lies 10° above the southeastern horizon at 10 P.M. local time. By mid-June, the planet is double that altitude at the same hour. The challenge for Northern-Hemisphere observers during this apparition is that Jupiter never rises higher than 30°. Opposition occurs June 5, when Jupiter shines at its brightest — magnitude –2.6.

Jupiter begins the month 7.5° northeast of Antares, the brightest star in the neighboring constellation of Scorpius the Scorpion. By June 30, it will have closed to within 5° of the star. Note their contrasting colors. Jupiter reflects starlight from a yellowish dwarf star (our Sun). This makes the ruddy hue of Antares, a cool,



OUTBOUND COMET ENCKE swings past Fomalhaut, the brightest star of the southern constellation Piscis Austrinus, in late June. *ASTRONOMY:* THEO COBB

ENCKE'S DIVE TREATS EARLY RISERS

Unexpected comets appear in our skies more often than you might think. Last October, C/2004 M4 (SWAN) brightened past the Hercules globular cluster M13. And in January, Comet McNaught (C/2006 P1) gave skygazers a once-in-a-decade performance. Be sure to check out Astronomy.com for late-breaking comet news.

While many of the best comets come as surprises, some of these primordial snowballs are quite predictable. 2P/Encke pays us a visit every 3.3 years. The comet's activity and brightness, based largely on its changing distances to the Sun and Earth, is almost as regular as its arrivals and departures.

Now, Comet Encke resides in the morning sky as it recedes toward the asteroid belt's outer fringes. Dropping below magnitude 11, Encke is fainter and smaller than any of the Messier galaxies. You'll need a scope 8 inches or bigger. Observe from well outside the city, and look low in the southeast after 3 A.M. It's best to wait until midmonth, when moonlight has left the morning sky.

Your guidepost is the bright star Fomalhaut, the luminary of Piscis Austrinus. In fact, for a few nights around the solstice, the glare of this sparkling white star will overwhelm the comet's feeble glow. Fomalhaut's name, as with so many of our stars, comes from Arabic and means "fish's mouth."

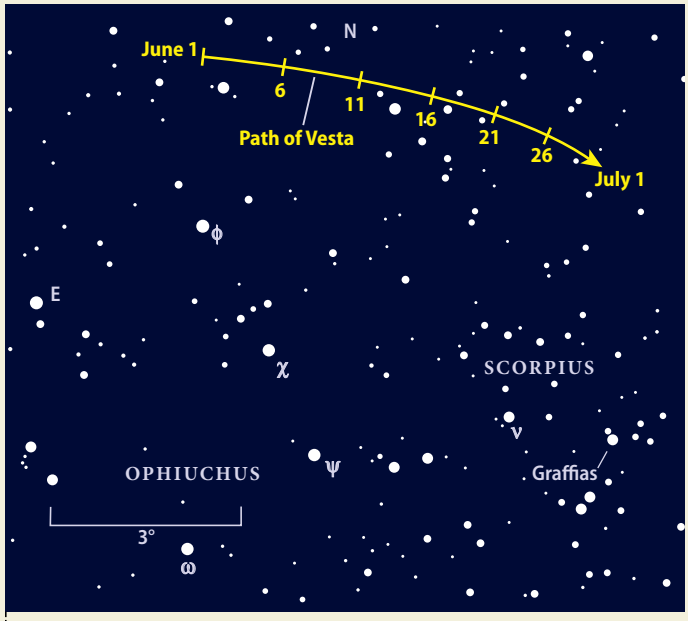
VESTA: FOR YOUR EYES ONLY

About every 4 years, the 300-mile-wide (500 kilometers) asteroid 4 Vesta brightens enough to be seen without optical aid from rural skies. Vesta reflects a surprising amount of sunlight. Although 1 Ceres, the first asteroid discovered, is almost twice its size, Vesta's surface is almost 4 times as reflective.

Vesta's elliptical orbit periodically brings it closer, then farther from the Sun. On May 31, Vesta reached its closest point (perihelion) to the Sun about a month before Earth reached the farthest point (aphelion) in its own orbit. This means the two objects are about as close together as they can be. When it comes to brightness, two things count: reflectivity, or albedo, and distance. Every doubling of distance dims the light we receive by 4 times.

Fortunately for naked-eye observers, Vesta lies in a fairly empty patch of sky, near a trio of bright stars — Phi (ϕ), Chi (χ), and Psi (ψ) — at the base of Ophiuchus and north of bright Antares in neighboring Scorpius. Nearby, there are only two magnitude 6 stars, both fainter than Vesta's magnitude 5.4.

If you're having trouble, pick up Vesta with binoculars first. Then give your unaided eyes another try. Avoid constantly checking a finder chart. You may need to make the attempt over several nights before you find one when the right conditions favor seeing Vesta. Don't give up too easily!



ASTEROID VESTA is a naked-eye treat. The space rock arcs from Ophiuchus into Scorpius this month. *ASTRONOMY:* THEO COBB

red supergiant star, all that more noticeable.

Jupiter's disk spans 46" — the largest of any superior planet. This means even small telescopes (60mm aperture) can spot some of the planet's striking atmospheric features.

Tracking the four, large, so-called Galilean moons of Jupiter is easy. Galileo discovered the satellites in 1610. Speedy Io orbits Jupiter in 1.8 days. It moves so fast, its positional changes are visible in minutes. Observers need a little more time to see the other moons move. During each month, Europa goes around Jupiter about 4.5 times, Ganymede twice, and Callisto once.

Pluto reaches opposition June 19. It lies in extreme northwestern Sagittarius, not far from the magnitude 3.4 star Xi (ξ) Serpentis. The dwarf planet shines at a challenging magnitude 13.9. Finding it requires a detailed star chart, a scope of at least 8-inches' aperture, and excellent dark-sky conditions. Pluto's location — exactly due west of the Omega Nebula (M17) — helps telescopic observers home in on the target. On June 1, Pluto is 7° away from M17, and it pulls another 45' away by June 30. This makes it easier to center the correct field of view.

Neptune is in Capricornus about 2.3° north of Gamma (γ) Capricorni. As June opens, the planet rises around 1 A.M. local daylight time. It begins retrograde motion in June, and this westerly track against the background stars picks up speed as the month progresses. You can pick up the magnitude 7.9 object using just tripod-mounted binoculars.

Uranus rises 75 minutes after Neptune and lies within 1.5° of Phi (ϕ) Aquarii, a magnitude 4.2 star in eastern Aquarius. By the end of June, Uranus slows its easterly motion and stops within 7' of the magnitude 5.5 star 96 Aquarii. Given Uranus' magnitude of 5.8, a binocular view of the pairing creates the illusion of a double star, which makes the planet easy to spot. The planet's tiny greenish disk spans 3.9'.

JUPITER MAKES an attractive target for off-world scopes, too. The HiRISE camera aboard NASA's Mars Reconnaissance Orbiter, which arrived at the Red Planet in 2006, acquired this image of the giant planet January 11, 2007. NASA/JPL/UNIV. OF ARIZONA

Mars remains below 6" diameter — a tough object, but easily visible to the naked eye. It lies in Pisces and rises by 3:30 A.M. local time. Its bright (magnitude 0.8) ruddy glow makes Mars easy to spot.

The **Sun** spends most of June within the constellation Taurus the Bull. It crosses into Gemini June 21, which is also the occasion of the summer solstice at 2:11 P.M. Eastern Daylight Time.

Saturn's sweet surprises

Nearly 3 years into its planned 4-year mission, the Cassini spacecraft must be filling in a few final gaps in its observational coverage of Saturn — right? Not so fast. In just the past several months, Cassini detected new rings circling the giant planet and imaged ring spokes that hadn't been seen clearly since the Voyager spacecraft encounters in the early 1980s. And on the haze-shrouded, planet-sized moon Titan, Cassini uncovered a massive mountain range and discovered the holy grail for Titan researchers: lakes of liquid methane.

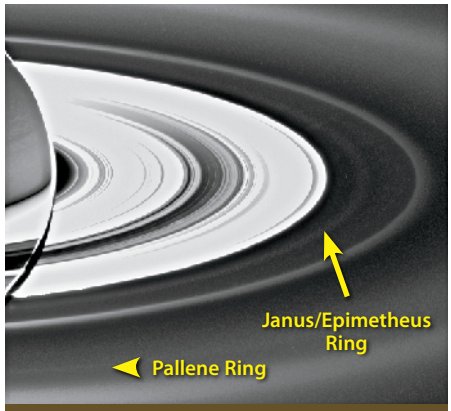
Despite all the scientific breakthroughs, Saturn remains first and foremost a world of beauty. Never has that been better illustrated than on September 15, 2006, when Cassini snapped an image of Saturn and its rings from inside the planet's shadow (above). Or make that *images*: This remarkable panorama consists of 165 separate shots taken through three filters over the course of 3 hours. Scientists then combined the images to create the mosaic.

Cassini spent 12 hours in Saturn's shadow that day, the longest such occultation of its 4-year mission. Normally, the spacecraft zips through the shadow in an hour or so. On September 15, however, Cassini was far from Saturn (1.3 million miles [2.2 million kilometers]) and perfectly positioned to create the extended occultation.

More rings for Saturn

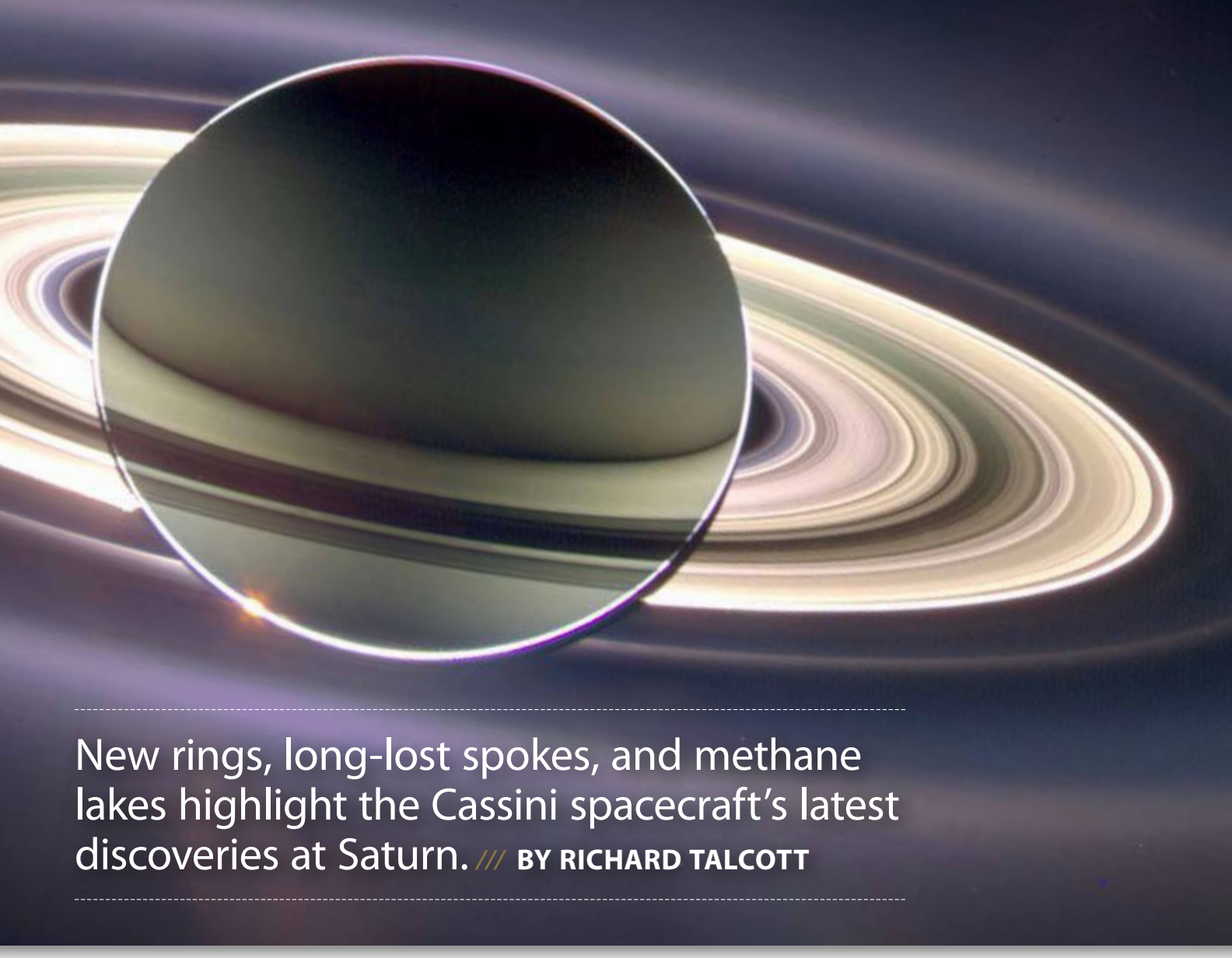
A pretty picture wasn't the only thing on Cassini scientists' minds. Viewing the whole ring system when it's brilliantly backlit brings to light the tiniest ring particles. So, this observation afforded scientists their best chance to find faint rings.

They weren't disappointed. Two tenuous new rings popped out of the image. One coincides with the shared orbit of the small moons Janus and Epimetheus, the other shares the orbit of Pallene, a moonlet Cas-



NASA/JPL/SSI

TWO NEW RINGS, both faint and diffuse, showed up in the backlit image. The Janus/Epimetheus ring has twice the diameter of the Pallene ring.



New rings, long-lost spokes, and methane lakes highlight the Cassini spacecraft's latest discoveries at Saturn. /// BY RICHARD TALCOTT

sini discovered in 2004. The first ring measures some 3,100 miles across (5,000 km) and lies between the bright main rings and the G ring. The second ring spans about 1,550 miles (2,500 km) and lies between the G and E rings. (For a complete rundown on all of Saturn's rings, see "Anatomy of a ringed planet" on page 56.)

These rings' proximity to small saturnian satellites is no accident. The moons don't have enough gravity to hold loose surface material tightly. So, whenever an interplanetary meteoroid strikes a tiny moon, material gets blasted off its surface and launched into orbit around Saturn, creating a diffuse ring.

"It's just like the old maxim that says 'Where there's smoke, there's fire,'" says Cassini interdisciplinary scientist Jeff Cuzzi of NASA's Ames Research Center. "At Saturn, where there's a new ring, there's bound to be a moon."

The occultation observation also presented scientists with their best view ever of the outermost E ring. This broad, diffuse structure, which starts 110,000 miles (180,000 km) from Saturn and spans some 190,000 miles (300,000 km), covers so much territory that previous images had to capture it one small section at a time.

Look closely, and you'll notice the E ring bulges on its left side, in the vicinity of the mid-sized saturnian moon Enceladus. Geysers erupting near Enceladus' south pole continuously replenish the ring with fresh ice particles.

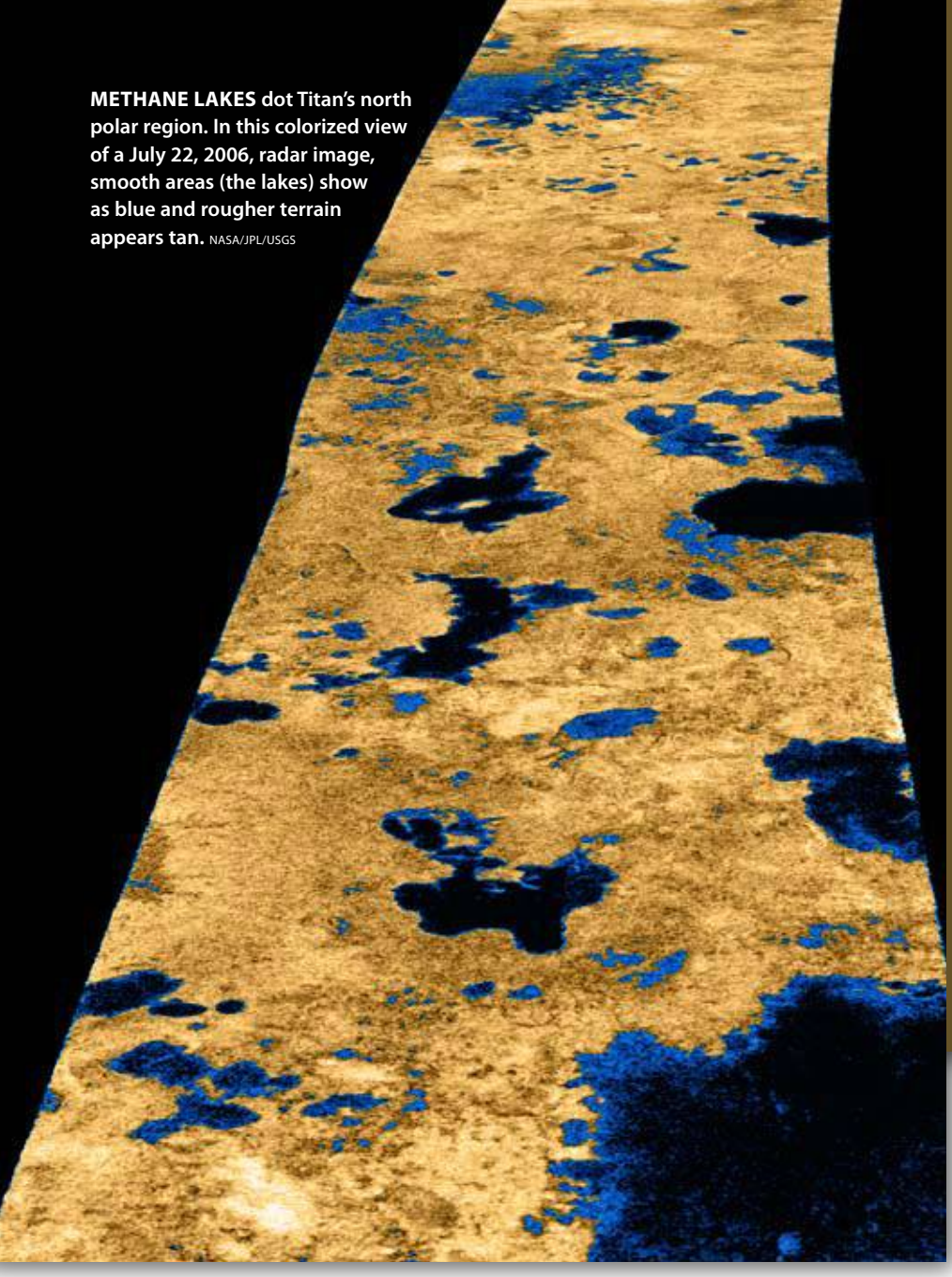
During this long occultation, Cassini had plenty of time to view the rings through most of its instruments. The spacecraft's Visual and Infrared Mapping Spectrometer (VIMS) shows distinct and unexpected color contrasts among the rings. The main rings appear neutral, the C ring reddish, and the D and E rings bluish. "We don't quite understand if these variations are due to differences in particle size or composition," says VIMS team member Phil Nicholson of Cornell University, "but it's nice to be surprised every once in a while."

ALL OF SATURN'S RINGS appear in this glorious panorama taken from within Saturn's shadow September 15, 2006. Cassini took 3 hours to make the 165 images that went into this exposure. NASA/JPL/SSI

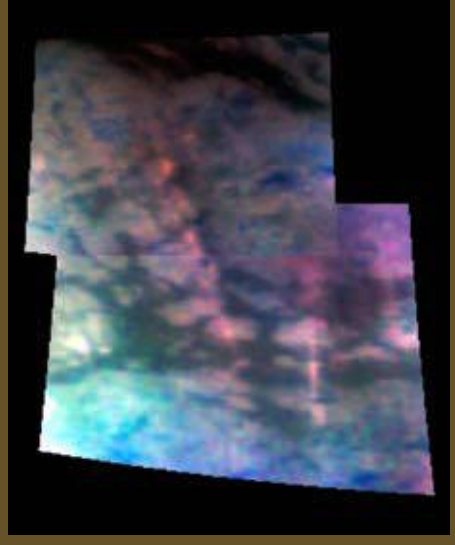
Return of the spokes

A surprise of a different sort awaited planetary scientists when Cassini reached Saturn in 2004. In the early 1980s, the twin Voyager spacecraft found ghostly spokes hovering above the bright main rings. These mysterious features appear as dark or bright streaks some 60 miles wide (100

Richard Talcott *is a senior editor of* Astronomy.

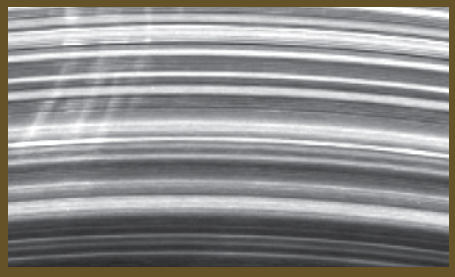


METHANE LAKES dot Titan's north polar region. In this colorized view of a July 22, 2006, radar image, smooth areas (the lakes) show as blue and rougher terrain appears tan. NASA/JPL/USGS



NASA/JPL/UNIVERSITY OF ARIZONA

THIS TITAN MOUNTAIN RANGE soars a mile high (1.5 km). Infrared images uncovered these peaks, which appear coated with bright deposits of methane snow.



NASA/JPL/SSI

RING SPOKES have returned to Saturn, now that the Sun shines less directly on the rings. In this September 2006 image, a group of bright spokes cluster in the B ring.

km) and up to 12,000 miles long (20,000 km). They form quickly — just after the outer portions of the B ring exit Saturn's shadow and return to sunlight — and usually dissipate several hours later.

Oddly enough, Cassini didn't see any spokes when it arrived. The spacecraft's first spoke sighting came in September 2005, and the number of sightings rose throughout 2006. Scientists now suspect spokes don't form when the rings get lots of sunlight (the situation when Cassini arrived). As the Sun sinks lower during the next 2 years, the spoke count should continue to rise.

Perhaps the observations will help planetary scientists figure out how the spokes develop. Experts think the spokes consist of tiny, charged dust particles levitated out of the rings' plane by electromagnetic forces. With more observations planned, researchers hope to test the various models.

Land of lakes

While Saturn's rings yield their secrets to Cassini's probing eyes, enigmatic Titan has tried to hold on to its mysteries. It's a losing battle. Over the past several months, Cassini's radar has found lakes on the moon's surface, and VIMS has imaged a massive mountain range.

Nothing pleases Cassini scientists more than finally seeing lakes. At Titan's frigid surface temperature of –291° Fahrenheit (–180° Celsius), the liquid isn't water, but, rather, methane or a combination of methane and ethane. Hydrocarbon smog permeates Titan's atmosphere, and scientists long suspected surface lakes helped maintain the atmospheric methane.

Since July 2006, the imaging radar has detected more than 100 lakes over far northern Titan, an area that has been immersed in winter darkness since before Cassini arrived. The biggest lake measures about 200 miles long (320 km), while the smallest is only 0.6 mile wide (1 km). Some have channels, which appear to have been carved by flowing liquids, leading into or out of them.

The lakes appear dark on the radar images because smooth regions don't reflect radar signals. "What we see is darker than anything we've ever seen elsewhere on Titan," says Larry Soderblom, a Cassini interdisciplinary scientist at the U.S. Geological Survey. "It's almost as though someone laid a bull's-eye around the whole north pole of Titan."

More lakes turn up every time Cassini passes over Titan's high arctic. "Titan has

FAR ABOVE THE RING PLANE, Cassini captured this nearly face-on view January 19, 2007. The Sun lay on the opposite side of the rings, so the dense B ring appears dark. The long exposures needed to record the dark rings caused the planet's sunlit half to be overexposed. NASA/JPL/SSI

SATURN'S MAIN RINGS show stark differences in this natural-color mosaic. Cassini was about 1.1 million miles (1.8 million km) from Saturn and 4° south of the rings' plane when it took this photo December 12, 2004. NASA/JPL/SSI

turned out to be like a musical crescendo — each pass is more exciting than the last," adds Soderblom.

The October flyby also revealed the tallest mountains seen on Titan to date. VIMS took the highest-resolution infrared images of Titan yet, seeing features as small as 1,300 feet across (400m). The mountain range is about 90 miles long (150 km), 18 miles (30 km) wide, and reaches nearly a mile (1.5 km) into the sky.

Deposits of bright, white material — possibly methane snow or other organic material — coats the top of the mountain ridges. "There seem to be layers and layers of various coats of organic 'paint' on top of each other on these mountain tops," says Soderblom, "almost like a painter laying the background on a canvas."

The mountains also may contribute to a band of clouds in Titan's mid-southern latitudes that occasionally extends much of the way around the moon. The clouds probably consist of methane droplets that have condensed into clouds as easterly winds push the atmosphere over the mountains. The same process creates clouds of water vapor on Earth and Mars.

Scientists think Titan's mountains show tectonic forces at work. Material likely welled up from below to fill in gaps as plates pulled apart, similar to the way Earth's mid-ocean ridges form.

Most of Cassini's observations during 2006 were of Saturn, its rings, and Titan. Although the spacecraft also targeted many of the planet's other moons, those encounters were at significant distances. In early 2007, Cassini's orbit carried it far above and below Saturn's ring plane. The unprecedented perspective afforded scientists a nearly face-on view of the rings (above), one they had never seen.

Later this year, Cassini will make close passes by heavily cratered Tethys, icy Rhea, and two-toned Iapetus, in addition to several more encounters with Saturn and Titan. The flybys promise great science, but they'll be hard-pressed to equal the excitement of recent results. Of course, similar "predictions" have turned out to be wrong. A

ONLINE EXTRA For more stunning images of Saturn and its moons, visit www.astronomy.com/toc.

Anatomy of a ringed planet

Saturn's beauty comes at a cost — and it's the moons that pay.

/// BY FRANCIS REDDY; ILLUSTRATION BY ROEN KELLY; IMAGES: NASA/JPL/SSI

Sporting splendid rings and 56 known moons, Saturn, the solar system's second-largest planet, is a beehive of activity. The three rings observers marvel at through earthly telescopes — the bright, broad A and B rings and the translucent C ring — likely formed millions of years ago, when Saturn's gravity shattered a moon that strayed too close.

But even today, some of the planet's moons sacrifice themselves to add to the rings' glory. A constant flux of meteoroid impacts grinds matter off the smaller moons, such as Atlas, Pallene, and orbit-sharing Janus and Epimetheus. Geysers at the south pole of Enceladus spew the ice and dust that supply Saturn's E ring.

Prometheus and Pandora together herd F-ring particles as fine as smoke, inducing braids and kinks unimagined until spacecraft photographed them. The gravitational influence of Mimas, which lies far outside the bright A and B rings, creates the rift — called the Cassini Division — that separates them. Telesto, Calypso, Helene, and Polydeuces are, in a sense, moons of moons. They circle Saturn, trapped in gravitationally stable points that lead and follow Tethys and Dione.

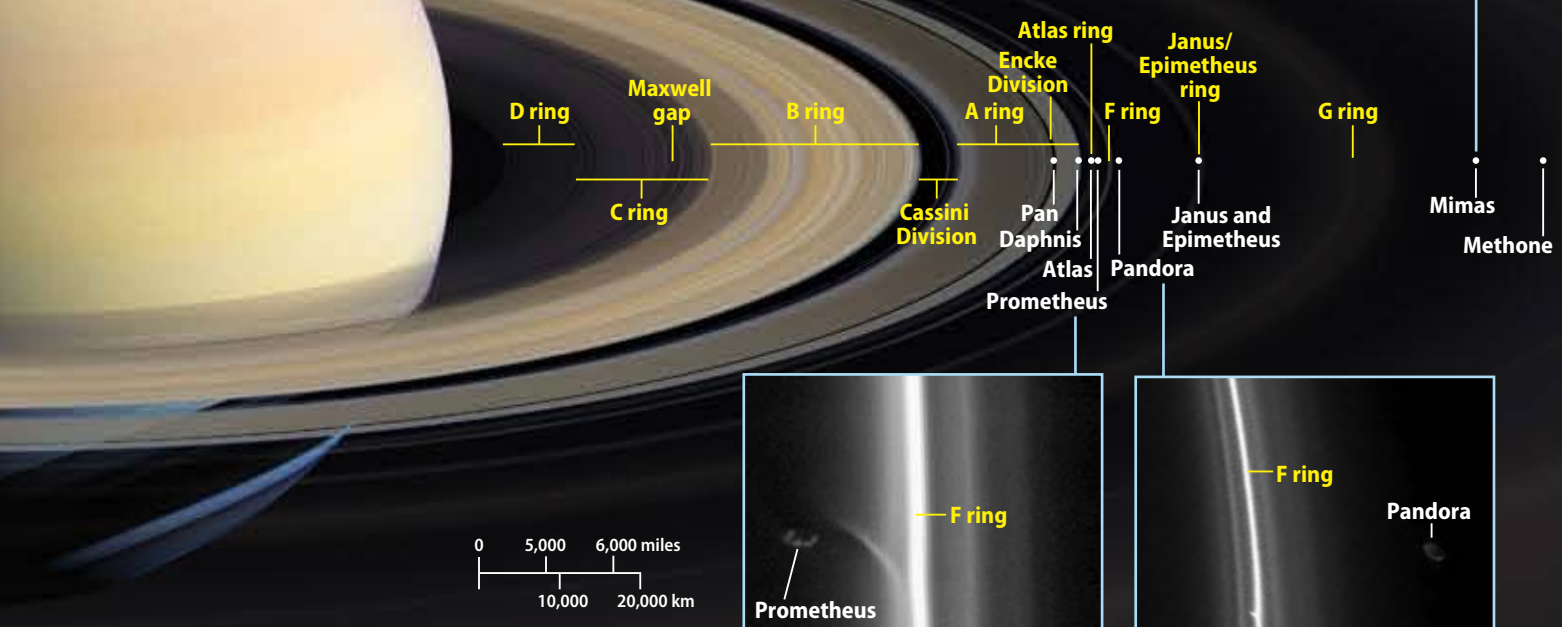
Many of the ragtag outer moons likely formed elsewhere, only to be captured when they wandered too close to Saturn. Distant Phoebe, the largest of these "irregular" satellites, may be the source of the material that darkens one side of Iapetus.

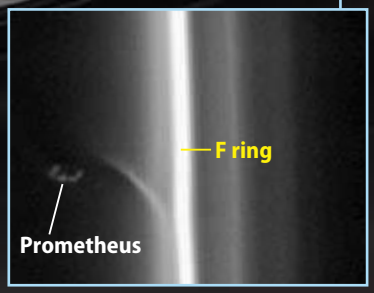
Rings and moons

FROM THE D RING to Dione, this plot shows Saturn's rings, ring gaps, and the orbits of its inner moons.

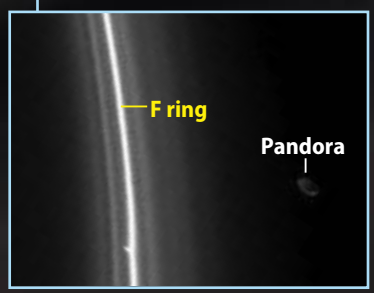
Rings and gaps are labeled in yellow.
Moons are labeled in white.

RINGS and their shadows arc across Saturn. The B ring's shadow is the darkest.



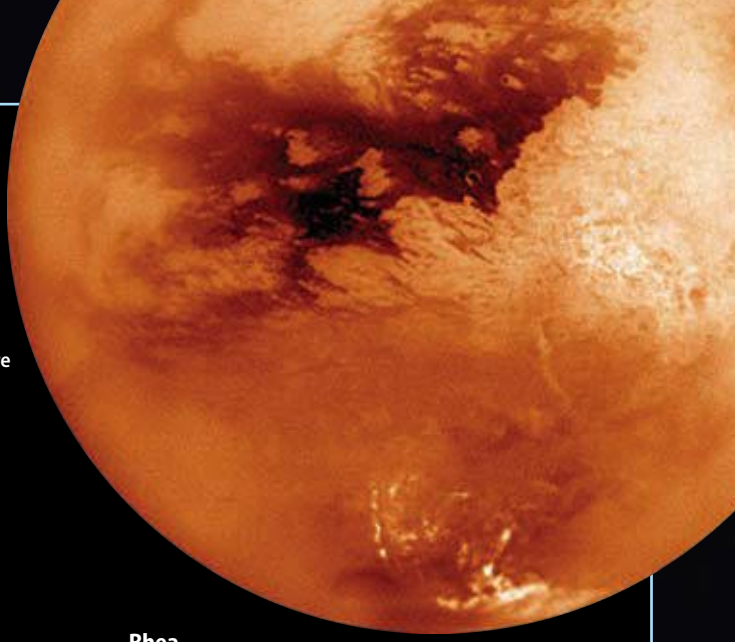


PROMETHEUS orbits inside the F ring. The moon's gravity drives a visible ripple in the ring's fine dust.



PANDORA circles Saturn outside the F ring and, together with Prometheus, corrals the ring's dust.

Saturn's variety of moons



Titan
Second-largest moon in the solar system; only satellite with an appreciable atmosphere

Phoebe
Hyperion
Tethys
Dione
Prometheus
Pandora
Shepherd the F ring
Iapetus
Epimetheus
Janus
Periodically swap orbits
Rhea
Mimas
Its gravity creates the Cassini Division
Enceladus
South-polar geysers supply E-ring particles

Rhea, Dione, and Tethys all orbit within Saturn's E ring

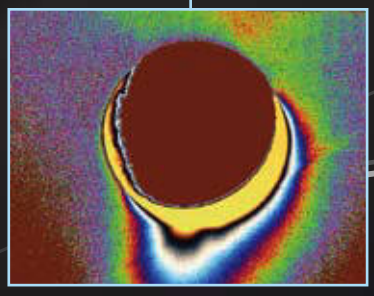
0 500 1,000 miles
1,000 2,000 km
Diameter of Earth's Moon
2,160 miles
3,476 km
Diameter of Titan
3,200 miles
5,150 km

Magnified 5 times

Pan
Atlas
Daphnis
Methone
Pallene
Helene
Polydeuces
Captured by Dione
Telesto
Calypso
Captured by Tethys

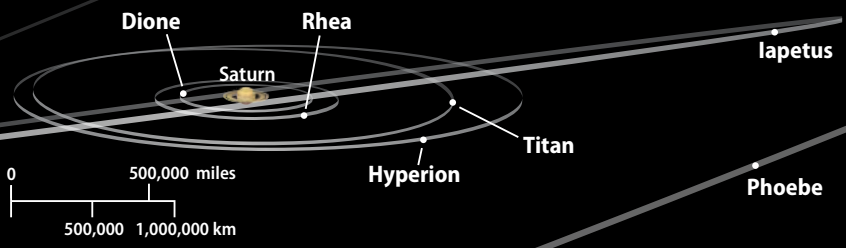
0 50 100 miles
100 200 km

Pallene ring
Pallene
E ring
Enceladus
The E ring spans more than 186,000 miles (300,000 km).
Tethys
Dione



ICY JETS issue from Enceladus' south pole in this February 2005 false-color image from NASA's Cassini orbiter.

Outer moons



PHOEBE'S INCLINED and retrograde orbit suggests Saturn captured it as a passerby. Debris ejected from Phoebe by impacts may coat Iapetus' dark leading hemisphere.

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One of two new ED refractors is this **Astro-Tech AT80EDT**. It has 80mm f/7 ED *triplet* optics; a dual-speed 2″ rotating Crayford focuser with both 2″ and 1.25″ compression ring eyepiece holders; the same dual-purpose equatorial dovetail as the AT66ED; and a hard carrying case. It is an outstanding optical value at only $649.

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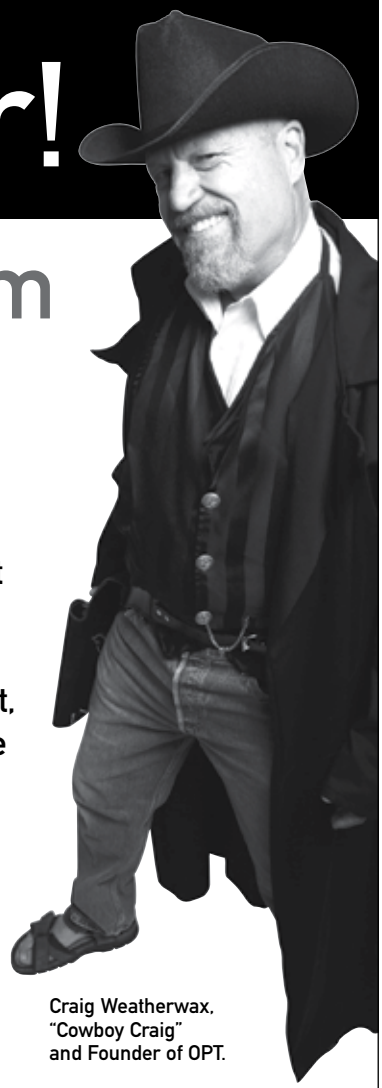

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To spice up your summer observing, zero in on these often overlooked deep-sky gems. /// BY STEVE COE

Explore forgotten Scorpius

Certain constellations remain fixed in

observers' memories. Take Scorpius, for example. Its distinctive shape and bright stars draw observers into its depths. French comet-hunter Charles Messier (1730–1817) listed four objects in Scorpius, two open clusters (M6 and M7) and two globular clusters (M4 and M80). But this constellation contains many other fine clusters and nebulae Messier overlooked during his comet hunts.

For most North American and European observers, Scorpius never climbs high in the sky; rather, it sits low on the southern horizon. Indeed, some observers never see the entire constellation. Because visibility is an issue, I've organized the descriptions so they start at the most northern object and finish at the southernmost. The easiest to view — for Northern Hemisphere observers — top the list. If the night isn't the best, or if you start observing when Scorpius has passed its best viewing location (due south), save the remainder of the targets for another night.

PLANETARY NEBULA NGC 6337 glows faintly and looks like a donut. NGC 6337 lies 2.5° southwest of magnitude 1.6 Lambda (λ) Scorpii. JACK MARLING

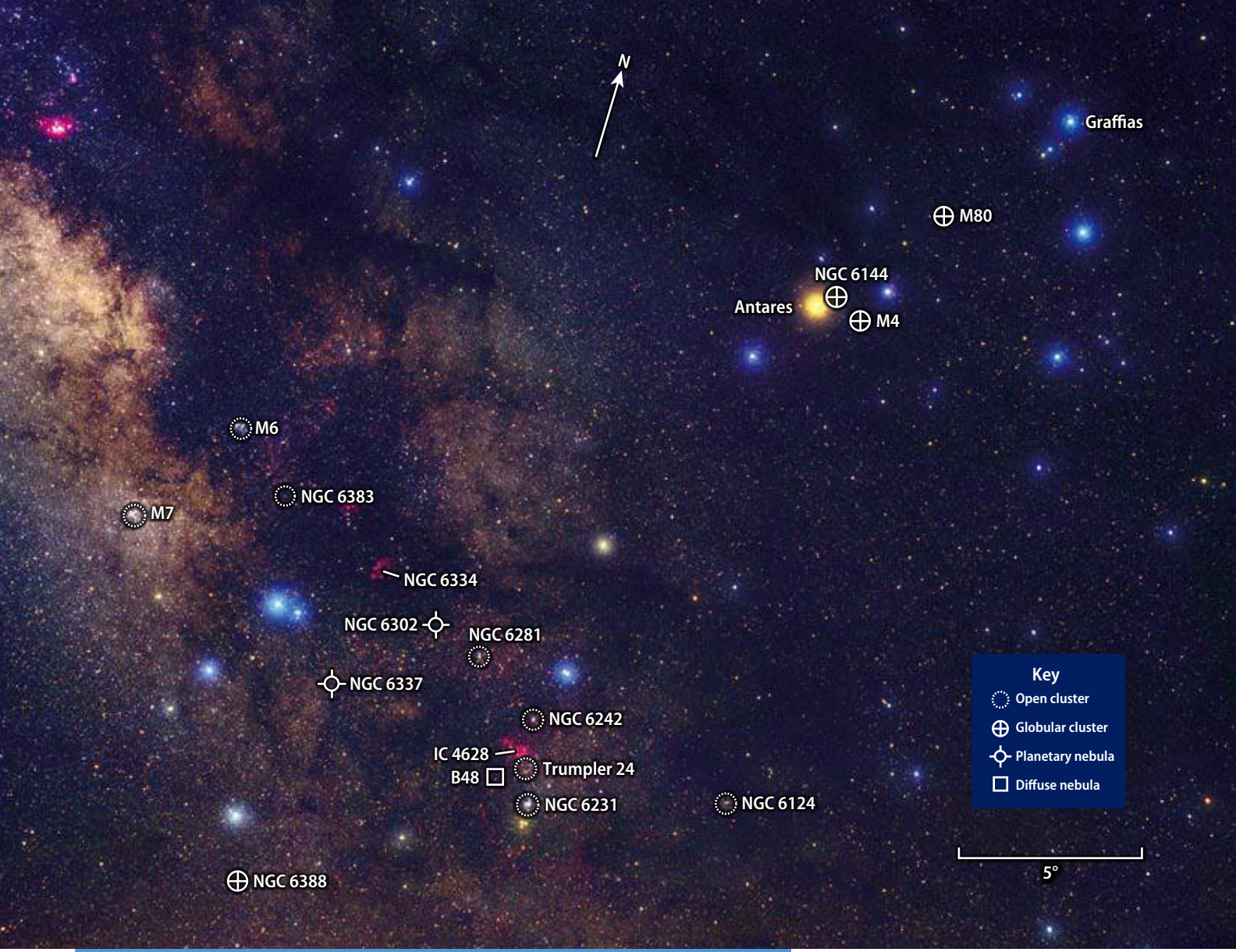
/// 19 FORGET-ME-NOT TREATS IN SCORPIUS

Name	R.A.	Dec.	Mag.	Size	Type
Graffias	16h05m	–19°48'	2.6	—	Dbl.
M80	16h17m	–22°59'	7.3	10'	GC
M4	16h24m	–26°32'	5.6	36'	GC
NGC 6124	16h26m	–40°40'	5.8	29'	OC
NGC 6144	16h27m	–26°01'	9.0	9.3'	GC
Antares	16h29m	–26°26'	1.1	—	Dbl.
NGC 6231	16h54m	–41°48'	2.6	15'	OC
Trumpler 24	16h57m	–40°40'	6.5	30' by 15'	OC
IC 4628	16h57m	–40°20'	—	90' by 60'	BN
B48	16h59m	–40°30'	—	45'	DN
NGC 6242	16h56m	–39°30'	6.4	9'	OC
NGC 6281	17h05m	–37°53'	5.4	8'	OC
NGC 6302	17h14m	–37°06'	9.6	0.8'	PN
NGC 6334	17h21m	–35°43'	—	40'	BN
NGC 6337	17h22m	–38°29'	12.3	0.8'	PN
NGC 6383	17h35m	–32°35'	7.0	20'	OC
NGC 6388	17h36m	–44°44'	6.7	6.2'	GC
M6	17h40m	–32°13'	4.2	25'	OC
M7	17h54m	–34°49'	3.3	80'	OC

Key: R.A. = Right ascension (2000.0); Dec. = Declination (2000.0); Mag. = Visual magnitude; Dbl. = Double star; GC = Globular cluster; OC = Open cluster; BN = Bright nebula; DN = Dark nebula; PN = Planetary nebula

Look near the top of the traditional constellation figure for **Graffias** (Beta [β] Scorpii), a double star in the Scorpion's head. Graffias is a relatively distant naked-eye star. It lies 580 light-years away. The stars shine at magnitudes 2.6 and 4.9. They lie 13.6" apart, so a magnification of 100x splits them easily. They appear white and light-blue through my 11-inch Schmidt-Cassegrain telescope (SCT). A third, 9th-magnitude component exists only 0.5" away, but seeing it lies beyond the capability of any telescope I've owned.

Globular cluster **NGC 6144** lies 40' northwest of Antares (Alpha [α] Scorpii). Such spheres, or globules, of stars formed long before the galaxy's spiral arms took shape. These clusters now move in elongated orbits around the Milky Way's center in a region astronomers call the galactic halo. NGC 6144 lies more than 30,000 light-years away. Our ancestors still lived in caves when the light from this globular started its journey toward your eyes.



SCORPIUS THE SCORPION is one of the few constellations that looks like its namesake. Use this guide to help locate the deep-sky objects in the story. We've also labeled Scorpius' four Messier objects. PHOTOGRAPH: BILL AND SALLY FLETCHER; GRAPHICS: *ASTRONOMY*: ROEN KELLY

With my 11-inch SCT at 200x through a 14mm eyepiece, NGC 6144 looks faint, large, a little brighter in the middle, and slightly elongated. The cluster shows 10 stars resolved with direct vision and several more with averted vision.

Averted vision works because your eye is more sensitive to light from a small, faint object if you look just a little off to the side of the object. NGC 6144 has a low surface brightness, so you'll need a dark night to observe this cluster at its best.

While you're in Scorpius' northern area, spend a little time on **Antares**. This famous luminary is also a double star. Usually, when the companion star shines at magnitude 5.6 and the separation is 2.7", the double splits easily. But not when the primary star is magnitude 1.1! Antares' brilliance makes this a difficult double to split.

I have split Antares three times, twice with a 17.5-inch scope (stopped down to 10 inches) and once with a 10-inch Newtonian reflector. All three splits occurred around twilight, so the brilliant glare of the 1st-magnitude star didn't overwhelm the 6th-magnitude secondary. At 250x, Antares appears yellow-orange and the companion is greenish. The green color may arise from a contrast effect with the orange primary creating, essentially, an optical illusion.

Open cluster **NGC 6383** is bright, small, triangular, and shows 11 stars at 100x through a 6-inch telescope. Open, or galactic, star clusters are groups of tens to hundreds of stars that formed together within our galaxy's spiral arms. NGC 6383 surrounds the double star h 4962. I split the double at 100x, and the stars appeared white and blue. Through the 9x50 finder scope, 7th-magnitude NGC 6383 appears as a bright spot compared to the fainter Milky Way background.

The **Cat's Paw Nebula** (NGC 6334) is a fascinating emission nebula that measures more than 1° across. It displays several bright areas superimposed on a faint background glow. My 13-inch Newtonian scope with a 22mm eyepiece shows it as faint and large with an irregular figure and 14 involved stars. Adding a nebula filter makes a big difference in the contrast.

I easily saw the four bright areas in the nebulosity through the filter. In fact, even my 11x80 finder scope presents an excellent view. I put a 20mm eyepiece with the nebula filter into the finder and saw a field aglow with the nebula. I also saw the four

THE CAT'S PAW NEBULA (NGC 6334) is a group of four bright nebulous patches. Because it's a large object (more than 1° across), use low magnification to get a wide field of view. Don't expect to see the red color through the telescope. This image combines a stack of ten 10-minute and ten 15-minute exposures to reveal the subtle hues. DON WESTERGREN

bright patches. Arizona observer Jay LeBlanc says this object reminds him of the Pleiades with dimmer stars and brighter nebulosity. See if you agree.

The **Bug Nebula** (NGC 6302) seems to have gotten its name because in photographs it looks like a squashed bug. The star embedded deep inside this glowing gas cloud is a white-dwarf star at the end of its life. A few thousand years ago, as the star shed the outer layers of its atmosphere, the star's hot core appeared. Ultraviolet light from its core causes the surrounding gas to glow and creates the nebula's two-lobed (bipolar) appearance.

The 11-inch SCT at 125x shows NGC 6302's bipolar nature. It appears small, bright overall, brighter in the middle, and elongated in a "figure 8" shape. The Bug's center is not stellar, even at 200x. Rather, it appears as a bright knot about 3" wide. A nebula filter will show some faint outer extensions of the nebula. Averted vision will help. Few bipolar nebulae exist, and this is one of the brightest, so put it on your observing list for next time out.

NGC 6281 is an open cluster that appears bright and large at 100x through a 17.5-inch Newtonian scope. I counted 30 stars in a rich Milky Way field. I could see several of the brighter members through the 9x50 finder scope.

NGC 6337 is a faint planetary nebula that looks like a dim donut. Through a 6-inch scope, it's difficult to see, and a nebula filter doesn't seem to help. Through the 11-inch SCT at 125x, it appears small and faint. Raising the power to 200x with no filter shows this object as two lobes. The left lobe has a star involved, and the right one is fainter, with a brighter spot much more obvious than the nebulosity. Adding a nebula filter makes all the difference; then, I can see the nebula's ring shape easily.

Open cluster **NGC 6242** lies just north of the Table of Scorpius. Through the 11-inch SCT at 125x it looks bright, large, rich, and shows an elongated V shape. I resolved 12 bright stars and several dozen fainter stars. An orange star sits at the southern edge. This cluster is about 3,000 light-years away.

IC 4628 is a faint, large, elongated nebula on the northern edge of Trumpler 24. Photographically, this nebula measures 90' by 60', but the most I've ever seen visually is about one-third that size.

Through a 4-inch refractor, I could barely see this nebula. I needed averted vision to glimpse it. Adding a nebula filter helped display this object with a lot more contrast — it appeared large and elongated with 16 stars involved within the nebulous glow. All of these observations of objects in the Table of Scorpius are from an excellent night in southern Arizona. But there is a way to see them better.

I have been fortunate enough to travel to Australia twice during the past 20 years. From a friend's backyard there, Scorpius

THE BUG NEBULA (NGC 6302) lies 4° west of Lambda (λ) Scorpii. This magnitude 9.6 planetary nebula measures 0.8' across. ADAM BLOCK/NOAO/AURA/NSF

Steve Coe *is a member of Phoenix's Saguaro Astronomy Club and author of* Observing Nebulae *(Springer Verlag, 2006).*

passes directly overhead. His 5-inch refractor displays Scorpius' clusters as sparkling star groups that jump out from the Milky Way background.

IC 4628 is a faint glow; and a dark nebula, **B48**, is an obvious elongated black area on the eastern side of Trumpler 24.

B48 is one of the dark regions of dust and cold gas cataloged by American astronomer Edward Emerson Barnard (1857–1923). Barnard published a list of 349 dark nebulae in *A Photographic Atlas of Selected Regions of the Milky Way*.

When hunting for B48, look for a crescent-shaped starless patch. Use low power.

North of NGC 6231 is **Trumpler 24**, an open cluster discovered by Swiss-American astronomer Robert J. Trumpler (1886–1956) in the 1920s. My 11x80 binoculars resolve 12 stars in a rather large cluster with a dark lane down the middle.

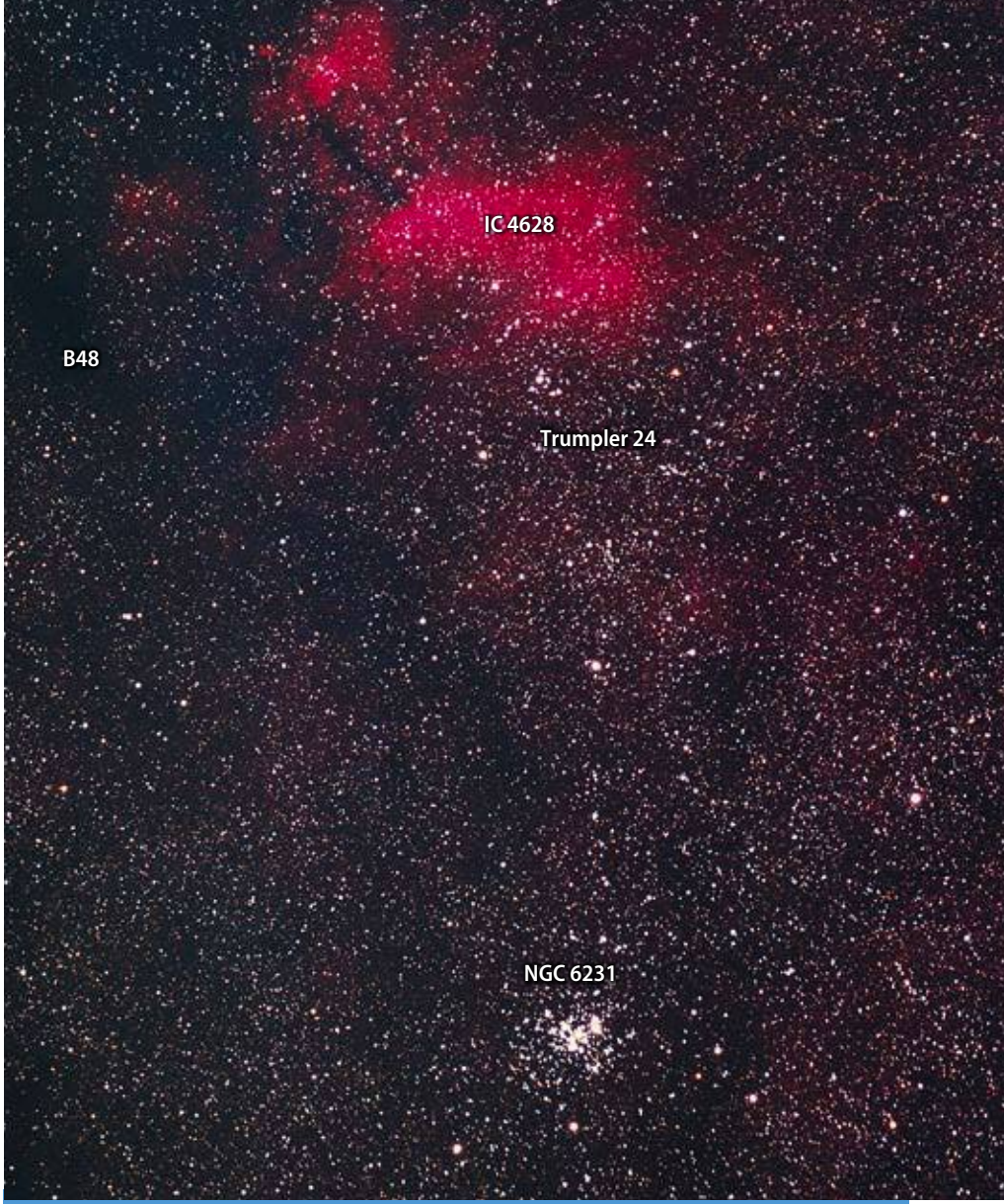
A 17.5-inch telescope at 60x shows this cluster as bright, large, and irregular. This huge cluster just fits into the 1° field of a 38mm eyepiece. This region of the Milky Way is rich, and this object stands out with a dozen bright stars and 100 dimmer stars.

Open cluster **NGC 6124** lies 1,500 light-years away. Europe was entering the Dark Ages when the light we see left those stars. I detect this cluster as a faint glow through 10x50 binoculars. Using my 11-inch SCT with a 22mm eyepiece, which yields 125x, this cluster looks bright, large, and somewhat compressed. I counted 33 stars fainter than magnitude 9. This cluster includes two double stars at this low magnification, both brightness-matched pairs.

NGC 6231 — at magnitude 2.6 — is the brightest open cluster in one of my favorite parts of the sky. At the place where the scorpion's body bends to the east is an obvious fuzzy spot that many call the "False Comet." Sure enough, it does look like a naked-eye comet, but that's probably not entirely how it got its name. A name for the wider region here is the "Table of Scorpius."

Both of those names probably originated with English astronomer Sir John Herschel (1792–1871), who observed from the Cape of Good Hope in South Africa from 1834 to 1838. Herschel sailed into False Bay when he arrived at the Cape and could see Table Mountain as he observed.

NGC 6231 contains seven bright, blue-white stars and lies about 6,000 light-years away. If it sat at the distance of the Pleiades (M45), 440 light-years away, NGC 6231's gigantic stars would form a cluster the same size as the Pleiades, but the stars would be as bright as Sirius! What myth would our ancestors have created from that pattern?



THREE SELDOM-SEEN objects accompany the bright open cluster NGC 6231 in this image. The red nebula IC 4628 is a difficult object to see through 6-inch and smaller telescopes. Trumpler 24 is a loose open cluster just to the south of IC 4628. B48 is a dark nebula cataloged by American astronomer Edward Emerson Barnard (1857–1923). TONY AND DAPHNE HALLAS

Use 11x80 binoculars to encompass this area perfectly. Big binoculars show the cluster is compressed. You'll resolve 12 stars in the cluster, and another 20 form a "spray" around it. Using a 13-inch Newtonian reflector at 100x, this cluster looks bright, large, triangular, and compressed toward the center. At 220x, I counted 53 stars in NGC 6231's northeast quadrant. So, more than 200 stars must have been visible.

In the far southern part of Scorpius, less than 1° from the Ara border, you'll find **NGC 6388**, a prominent globular cluster situated in a dark field of view. It appears fuzzy through the finder scope. Using a 17.5-inch Newtonian at 165x, it appeared bright, large, and much brighter in the middle. This globular looks grainy at all powers and shows six stars resolved at 220x.

This summer, set up your telescope and look toward our galaxy's heart. With a little perseverance, you'll find Scorpius offers some great under-the-radar treats. A small scope is all you need, but an 8-inch or larger instrument will show you more than Messier ever could have dreamed.

ONLINE EXTRA Download an Autostar tour of these objects for your Meade telescope at www.astronomy.com/toc.

ASK ASTRO

This month:
- Why do some meteors travel faster than others?
- Is space the only thing expanding in the universe?
- Why is the Moon slowly moving away from Earth?

METEOR SPEED

Q: Why do some meteor showers, such as the Geminids, have slower-moving meteors, while others, like the Perseids, have faster-moving meteors?

— **TAHMI HALL,** WYOMING, MINNESOTA

A: Meteors follow different orbits and collide with Earth at different angles. This is why some shower meteors are faster than others.

The dominant factor is the meteors' motion relative to Earth's. Meteors that move in low-inclination orbits — like the Leonids — can collide with Earth almost head on. Leonid speeds are among the highest of the meteor shower, up to 161,000 mph (259,000 km/h).

Draconid shower meteors have higher orbital inclinations and travel in the same direction as Earth. This results in hits "from the side," so their speeds are lower.

The angle of the encounter determines not only the shower speed, but also the radiant (the direction from which the meteors appear to originate). If the geometry changes, the radiant's direction also changes. Earth is in constant motion around the Sun, which results in the shower radiant slowly changing location over time — as does the meteors' speed. Meteor observers call this effect "radiant drift."

For short-duration showers, such as Leonid outbursts, the radiant drift is insignificant. But for a shower of longer duration, such as the Orionids, radiant drift can be quite noticeable — up to several degrees.

Another good example of this is the Perseid meteor shower. Around the beginning of shower activity, on July 20, the radiant is at R.A. 0h44m, Dec. 52°. On August 10, it is at R.A. 3h0m, Dec. 57°. Near the shower's end, on August 25, the radiant is at R.A. 4h12m, Dec. 58°. This shower's radiant changes by some 30° during the course of the shower from July 20 to August 25.

Shower meteors share similar orbits to their parent bodies, comets — except in the case of the Geminids and Quadrantids. These showers' meteors are fragments of what appear to be asteroids.

If the parent has an elliptical orbit, its meteors are faster when they reach Earth than those associated with a parent in a more circular orbit. For example, the orbit of Comet Swift-Tuttle — the origin of the Perseid meteors — is much more elliptical than the Geminids' parent, the asteroid Phaethon. This is why Perseid meteors are faster than Geminids.

— **BILL COOKE,** NASA/MARSHALL SPACE FLIGHT CENTER, HUNTSVILLE, ALABAMA

LEONID METEORS streak across the Arizona sky against a background of star trails. The Leonids travel at a fast-paced 158,000 mph (71 km/s). The Perseids are slower-moving, at 134,000 mph (60 km/s), while the Geminids move at a leisurely 78,000 mph (35 km/s). JOSHUA VAUGHAN

EXPANDING UNIVERSE

Q: If the universe is expanding, are atoms, particles, and people also expanding?

— **ALBERTO NYSSEN,** LOS ANGELES

A: This question seems simple, but its answer quickly gets into some of the most fundamental concepts in cosmology. Let's start with the Hubble expansion. It is not, as it is sometimes pictured, an explosion in which matter moves through space. Instead, space itself expands, with matter (atoms, particles, and people) carried along like a leaf in a stream.

My favorite analogy is the bread-dough model. Imagine raisins in a rising dough: As the dough expands, the raisins move apart from each other. This is the kind of expansion we see in the cosmos. The question is whether raisins within the dough also expand.

The expansion moves any two points farther apart from one another. In an atom, this would mean the "dough" between the nucleus and the electrons would expand, moving the two apart. Thus, the Hubble expansion moves the parts of the atom, like the galaxies in the universe, farther apart from each other. **The expansion is so small for an atom that it would never be detected, but it is there in principle.**

The discovery of dark energy and the accelerating Hubble expansion introduces an interesting twist. Think of dark energy as a kind of anti-gravity that pushes objects farther apart, much like gravity pulls objects together.

Some theories predict dark energy's strength grows with time. This leads to what cosmologists call the Big Rip — when the repulsive force becomes strong enough to tear atoms apart.

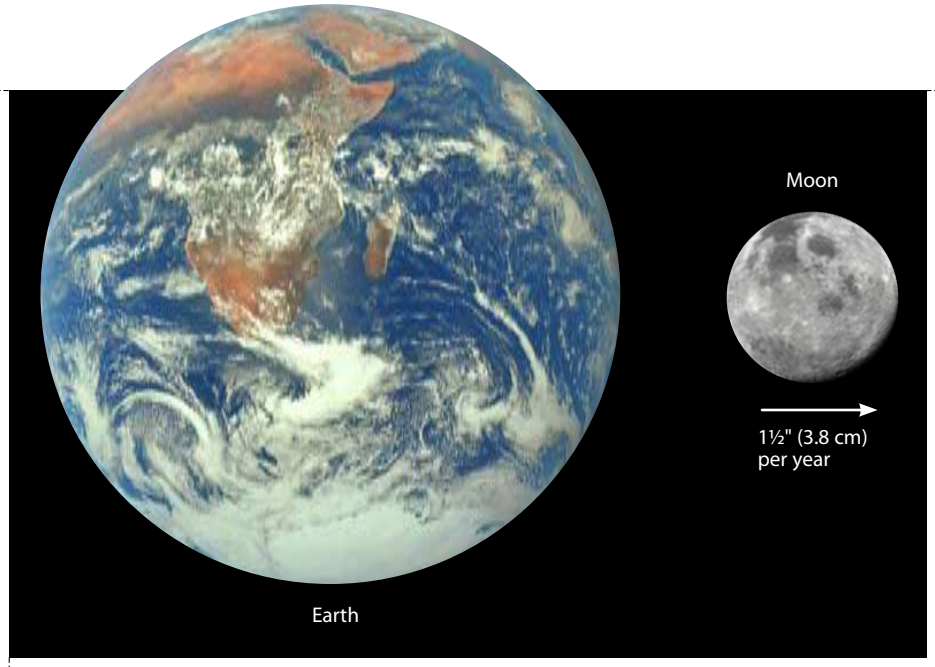
If you follow this line of reasoning to its conclusion, you might imagine the quarks that make up elementary particles being ripped apart; or, possibly, the strings that some people think make up the quarks being stretched into non-existence. Few theorists take this scenario all that seriously, so there's no need to sell your beachfront property just yet! — **JAMES TREFIL,** CLARENCE J. ROBINSON PROFESSOR OF PHYSICS, GEORGE MASON UNIVERSITY

RECEDING MOON

Q: Why is the Moon's orbital distance increasing over time? — GENE SOLLOWAY, EDMOND, OKLAHOMA

A: The Moon's increasing distance has to do with a physics concept called angular momentum, which is a body's resistance to a change in its rotation or orbit. If we look at the Earth-Moon system, we find two sources of angular momentum — Earth, which rotates once every 24 hours, and the Moon, which orbits the Earth every 27.3 days.

The Moon also rotates, but Earth's gravitational influence has slowed the Moon's rotation to the point that it always keeps the same face pointed toward us (a phenomenon called tidal locking). Thus, the Moon rotates once every 27.3 days.



EARTH AND THE MOON are moving away from one another at a snail's pace of about 1½" (3.8 cm) per year. CENTER FOR PLANETARY SCIENCES, NORTHWESTERN UNIVERSITY

A fundamental physical law says the total angular momentum of a system — in this case, Earth and the Moon — must remain unchanged unless some outside force messes with it. Earth and the Moon constantly exert gravitational pulls on each other. Earth's pull has tidally locked the Moon's rotation, and the Moon's pull raises tides here on Earth.

The friction of the water being moved back and forth over the ocean floors has gradually slowed Earth's rotation over the eons — 900 million years ago, our day was only about 18 hours long. As Earth's spin slows, some of its angular momentum is lost.

But nature demands angular momentum be conserved. That means the Moon must increase its angular momentum to compensate for Earth's loss.

There are two ways to do this — speed up, which the Moon can't do, or increase its distance, which it can. So, over time, the Moon recedes from Earth.

This will continue until Earth's rotation has slowed to the point where the length of our day is the same as the time it will take the Moon to orbit Earth (until Earth becomes tidally locked to the Moon).

The bottom line: Tidal friction, caused by the Moon's gravitational influence, is slowing Earth's rotation rate. **Conservation of angular momentum requires that the Moon move away from Earth in order to compensate for Earth's loss of angular momentum.** — **BILL COOKE,** NASA/MARSHALL SPACE FLIGHT CENTER, HUNTSVILLE, ALABAMA

IN THE KNOW

LOW-INCLINATION ORBIT
An orbit in which the angle between a meteor's orbital plane and Earth's ecliptic is small.

RADIANT
The point in the sky from which the meteors belonging to a meteor shower appear to originate.

HUBBLE EXPANSION
Space expands and carries matter along like a leaf in a stream.

COMING NEXT MONTH ...

What will happen to people and objects when the Earth-Moon center of mass reaches Earth's surface? Post your thoughts, and see what others think, about this question online at www.astronomy.com/forums.

Send your questions via e-mail to: askastro@astronomy.com; or write to: Ask Astro, P. O. Box 1612, Waukesha, WI 53187. Be sure to tell us your full name and where you live. Unfortunately, we cannot answer all questions submitted.

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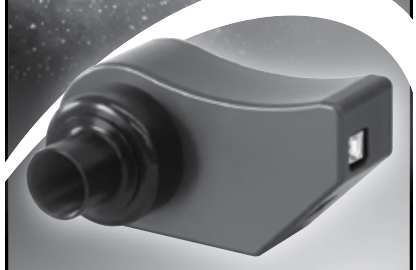

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An experienced skyshooter trades in film for pixels — and opens up a new world. /// **TEXT AND IMAGES BY JASON WARE**

How I discovered digital astroimaging

I was first on my block to have HDTV,

a satellite radio, and an autoguider. But when it came to CCD imaging, I was one of the last holdouts to trade in the darkroom for a silicon chip. I was comfortable with photography and its techniques, and I was getting great results.

I switched in 2005, when I realized CCD detectors had finally surpassed film for capturing celestial images.

Early CCD imagers praised the technology's sensitivity, citing short exposure times. However, they sometimes failed to admit the resolution of the primitive devices fell below that of fine-grain films.

Some early proponents also believed that, because CCDs are an electronic medium, they must be better. The reality was CCD cameras back then had small image detectors and low resolution.

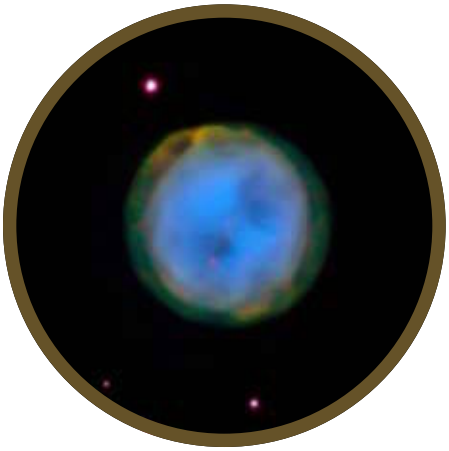
From film to digital

For astrophotographers, film still reigned because of its larger format. I used a medium-format 6x7 camera for many years coupled to a Meade 6-inch f/9 refractor for a wide field of view and superb images.

Sensor technology for digital cameras rapidly evolved and, in 2003, I purchased a Fuji S2 Pro digital single-lens reflex (DSLR) camera. The first few photos with this camera convinced me film was, indeed, on the way out. I tried a few astroimages but, because of the built-in infrared (IR) filter, my results were poor. Now, however, DSLR cameras can be modified for astronomical use by removing the IR filter. Several companies offer this service.

My early experiments gave me some exposure to the challenges of digital imaging, such as dealing with electronic noise (random white spots), hot pixels (permanent white spots), and flat frames (a technique to eliminate optical imperfections in the telescope and camera). DSLR technology has progressed considerably, and many amateurs produce images whose quality approaches that of dedicated astronomical charge-coupled device (CCD) cameras.

JASON WARE has been photographing the night sky since 1989. His images have appeared in many publications, as well as advertisements and museum exhibits. Ware is also an avid observer. He has a BSEE from Texas Tech University and currently works as an application engineer for Cadence Design Systems, a computer-chip design-software provider.



THE OWL NEBULA (M97) in Ursa Major is a planetary nebula — one of the final stages for Sun-like stars. The author used a Meade 12-inch RCX 400 telescope and a Yankee Robotics Trifid-2 6303E CCD camera, and took 2-hour exposures through Astrodon 6nm Sulfur II, Hydrogen-alpha, and Oxygen III filters.

THE CRAB NEBULA (M1) in Taurus shows many filaments, which resemble crab legs. This narrowband-filtered image shows details in Hydrogen-alpha, Sulfur II, and Oxygen III light. The author shot this image with a Yankee Robotics Trifid-2 6303E CCD camera attached to a Meade 12-inch RCX 400 telescope.

THE "PILLARS OF CREATION" lie within the Eagle Nebula (M16) in Sagittarius. For this tri-color image, the author used a Meade 12-inch RCX 400 telescope, a Yankee Robotics Trifid-2 6303E CCD camera, and Astrodon Hydrogen-alpha, Sulfur II, and Oxygen III filters. Exposure times were 100 minutes through the Hydrogen-alpha filter and 60 minutes through the other two filters.

An astroimager's equipment

THE AUTHOR'S large-aperture telescope of choice is Meade's 12-inch RCX400 telescope. Ware likes the RCX's larger corrected field of view as compared to Meade's LX200 line.

NARROWBAND FILTERS make color imaging possible under bright skies. Using a filter wheel, the author configures an automated session to take multiple exposures using different filters.

WARE'S CURRENT imaging setup includes a Yankee Robotics Trifid-2 6303E CCD camera, an Optec IFW filter wheel, and a Meade DSI Pro (for guiding).

THE AUTHOR uses a Palm Treo 650 running *Palm VNC* to monitor his 12-inch Meade RCX remotely. He uses *MaxIm DL/CCD* for telescope control.

WARE'S CURRENT imaging setup includes a Yankee Robotics Trifid-2 6303E CCD camera, an Optec IFW filter wheel, and a Meade DSI Pro (for guiding).

Astronomical CCD cameras also benefited from sensor-technology evolution. Today, they far exceed what can be done with film. In fact, a 12-inch telescope with a good CCD camera will reveal more contrast and detail than the 48-inch Palomar Mountain Schmidt camera sky-survey done in the mid-1950s.

Imaging from the city

Possibly the most impressive benefit of CCD imaging comes from the ability to use narrowband filters in light-polluted areas. This is because CCD detectors allow you to take an image of the background sky and electronically subtract it from the celestial object's image. Narrowband filters significantly reduce the energy reaching the detector, so exposure times must be long.

The good news is, because of the way imagers can stack CCD images, many short exposures can combine to produce one long exposure. This technique has the added benefit of canceling electronic noise and removing electronic artifacts such as cosmic-ray hits or small tracking errors.

Narrowband filters transmit only a small window of wavelengths. For example, a 6 nanometer (nm) Hydrogen-alpha (Hα) filter passes about 90 percent of the light from 3nm above to 3nm below the Hα emission line's 656.3nm wavelength. The filter blocks all other wavelengths. This reveals the target object in its full glory, no longer overwhelmed by humanmade or natural light-pollution. Note, however, that narrowband imaging is effective only on emission sources such as emission and planetary nebulae. Galaxies emit light across a wide spectrum, so the filter blocks their light along with city lights.

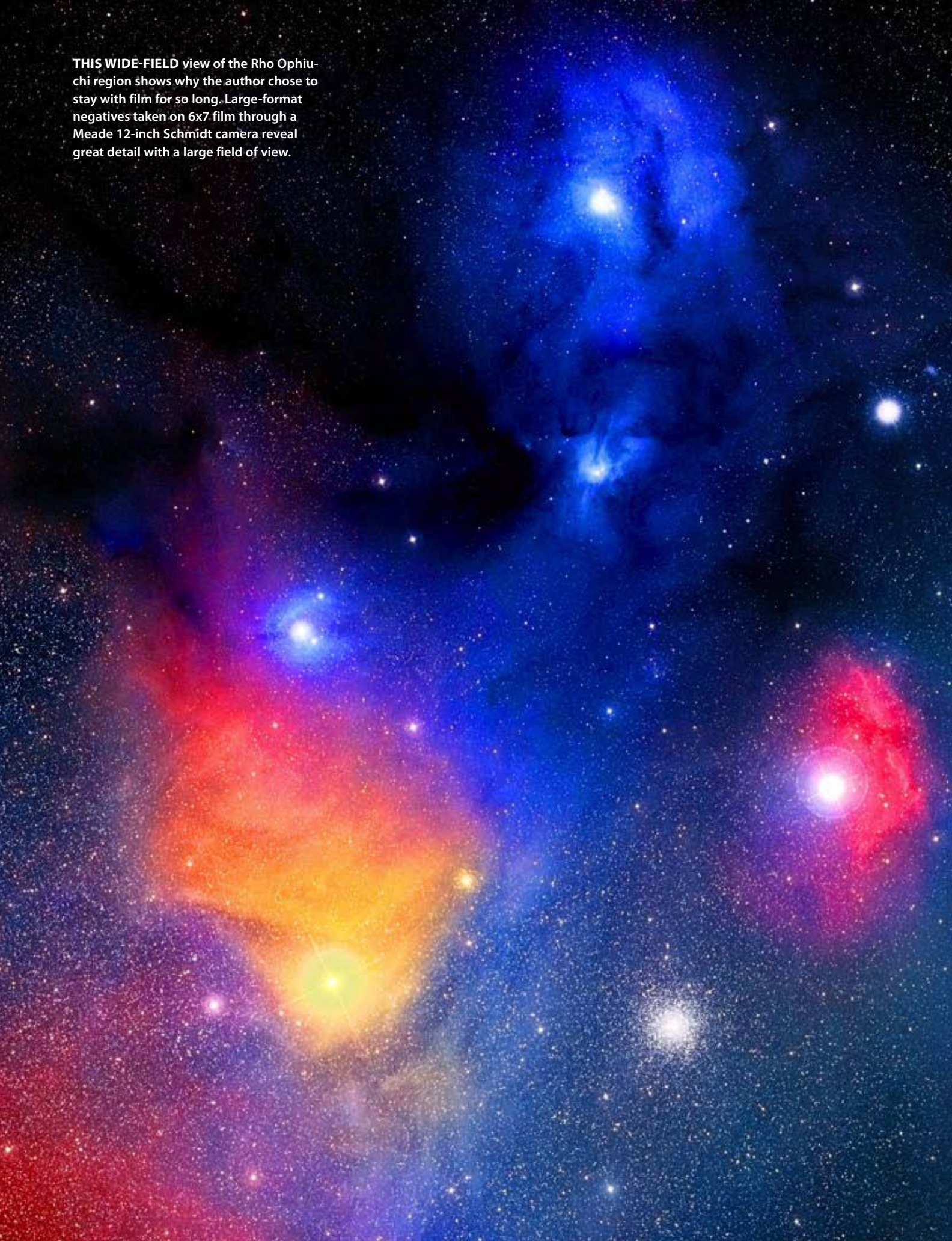
Automating the process

In addition to the wonderful imaging qualities of CCD cameras, another benefit sometimes gets overlooked. Because the CCD gives real-time feedback, you can automate many aspects of the imaging session: focusing, changing filters, finding a guide star, and composing the image. Some imagers control telescopes remotely from the comfort of their homes hundreds of miles away.

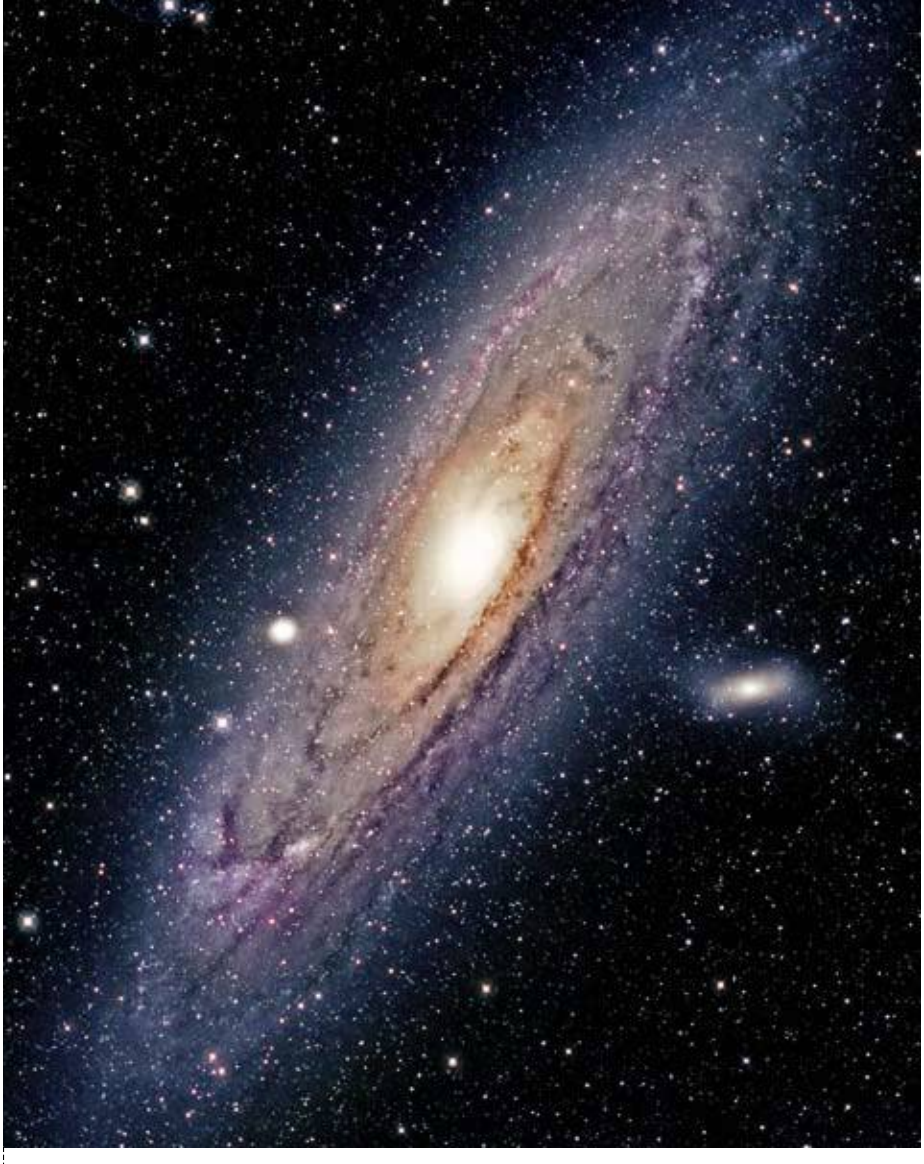
For camera and telescope control, I use *MaxIm DL/CCD*. This program can control

— continued on page 73

Jason Ware *is a long-time astroimager. To see more of his work, visit www.galaxyphoto.com.*



THIS WIDE-FIELD view of the Rho Ophiuchi region shows why the author chose to stay with film for so long. Large-format negatives taken on 6x7 film through a Meade 12-inch Schmidt camera reveal great detail with a large field of view.



THE ANDROMEDA GALAXY (M31) requires high resolution and a wide field of view. The author shot this image through a 16-inch Meade LX200 Schmidt-Cassegrain telescope with a custom-made 6x7 film camera attached.

THE PLEIADES (M45) is the brightest and closest Messier object. The author used a 12-inch Meade Schmidt camera and took two 60-minute exposures, one on Kodak Technical Pan film and the other on Fuji 400 color film. He later scanned the negatives and combined them with software.

THE ORION NEBULA (M42) is perhaps the sky's best-known nebula. The author used a Meade 12-inch RCX 400 telescope and a Yankee Robotics Trifid-2 6303E CCD camera. Exposure times were 4 hours through a Sulfur II filter, and 2 hours through Hydrogen-alpha and Oxygen III filters.

THIS TWO-COLOR image shows a lot of detail in the Dumbbell Nebula (M27). The author used a Meade 12-inch RCX 400 telescope and a Yankee Robotics Trifid-2 6303E CCD camera, and took 100-minute exposures through Astrodon Hydrogen-alpha and Oxygen III filters.

THE HELIX NEBULA (NGC 7293) in Aquarius looms large because it's only 450 light-years away. For this image, Ware used a Meade 12-inch RCX400 scope and a Yankee Robotics Trifid-2 6303E CCD camera. He took 100-minute exposures through Hydrogen-alpha and Oxygen III filters.

WARE FIRST MADE the transition from film astrophotography to digital imaging with a Fuji S2 digital single-lens reflex camera. One of his first images was of the Hercules Cluster (M13). He imaged M13 with the S2 from his home near Dallas through a Meade 16-inch LX200 telescope.

EMISSION NEBULA NGC 2174–5 in Orion covers more sky than the Full Moon. The author used a Yankee Robotics Trifid-2 6303E CCD camera attached to his 12-inch Meade RCX 400 telescope. This image combines a 3-hour exposure through a Hydrogen-alpha filter with 40-minute exposures through red, green, and blue filters.

THE ROSETTE NEBULA (NGC 2237–9) marks a region of space where star formation occurs. To create this image, the author used a Meade 12-inch RCX 400 telescope; a Yankee Robotics Trifid-2 6303E CCD camera; and Astrodon 6nm Sulfur II, Hydrogen-alpha, and Oxygen III filters. The final image combines 2-hour exposures through each filter.

— continued from page 70

an entire imaging session. With a plugin such as *CCD Autopilot*, I can image multiple targets automatically in a single night. *Autopilot* also can open and close an observatory dome and park the telescope — all while the owner sleeps. Another useful plugin is *PEMPro*. This program uses CCD images to measure and compensate for the periodic drive error on telescopes equipped with Periodic Error Correction.

Once you have automated a telescope and CCD camera, a new world of convenience opens up. Programs like *Remote Desktop* and *Virtual Network Computing* (VNC) allow users to monitor the telescope remotely from a computer.

I have installed *Palm VNC* on my Treo 650 Palm phone and can monitor an imaging session from anywhere I have a strong cellular phone signal. Recently, I started an imaging session at my home, left to play in a hockey game, then checked on the imaging progress shortly after leaving the ice. I found that, because of a gust of wind, my system had lost the guide star. While still in skates, I downloaded a new guider image, re-acquired the star, and continued the imaging session! Edwin Hubble and Wayne Gretzky both would be proud.

My imaging setup

In 2005, I began imaging with a 12-inch Meade RCX 400 telescope and a Yankee Robotics Trifid II 6303e CCD camera. This proved to be a perfect match.

The RCX's corrected field of view is much larger than that of Meade's previous LX200 line. The Trifid II's imaging chip fit the field perfectly. Only minor vignetting and field curvature show in the corners.

To complete the imaging "stack," I added an Optec IFW filter wheel and a set of Astrodon 6nm filters. This set, which contains Hydrogen-alpha, Oxygen III, and Sulfur II filters, enables the user to "map" each filter's image to a color pallet similar to that used by the Hubble Space Telescope.

With this setup, I have produced images that exceed my wildest dreams from the days when I started with grainy black-and-white film. For the most part, I image from my home in a light-polluted Dallas suburb about 25 miles (40 km) from downtown.

Now that I've made the switch to digital imaging, I'm here to stay. After years of resistance, I joined the ranks of those making the proclamation, "Film is dead!"

One of last century's most celebrated small telescopes is set to make a comeback. /// **BY MIKE D. REYNOLDS**

Rebirth of a classic: the Porter Garden Telescope

A backyard telescope is commonplace today. But 80 years ago, having one, especially a Porter Garden Telescope, set a person apart. The man behind this device influenced both amateur telescope-making and the largest professional telescope of his time. Now, a present-day company — Telescopes of Vermont — is ready to unveil a faithful reproduction of this classic instrument.

Big eye on the sky

An Arctic adventurer, architect, and artist, Russell Williams Porter (1871–1949) was a man with diverse interests. Porter's talent as a designer led to his involvement in the world's largest telescope project.

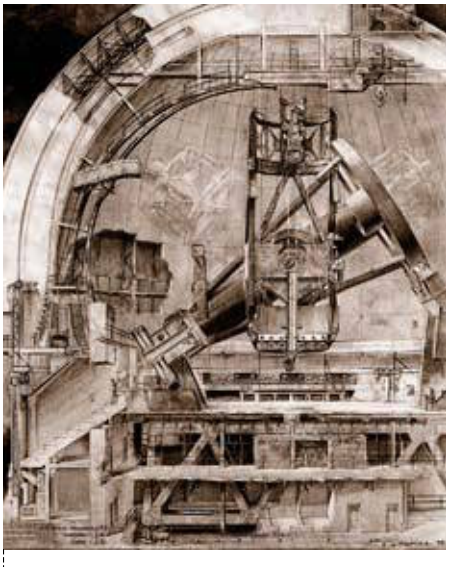
In the 1920s, American astronomer George Ellery Hale (1868–1938) was on a mission: to build the world's largest telescope. In 1928, Hale invited Porter to join the team of astronomers and engineers to design and build the world's largest telescope — the 200-inch reflector on Palomar Mountain in California.

Porter's skills as an artist, mechanical designer, and an architect, were invaluable. This project, the culmination of Porter's life, would last 20 years and see the dedication of Palomar Observatory in 1948.

World War II interrupted the Palomar work, yet everyone was busy. Porter assisted the Department of Defense though his combat-support equipment design work. Porter also organized amateur telescope-makers to make optical components to support the war effort.

Function plus style

Porter's ability to blend art, astronomy, and engineering is perhaps best represented by his Garden Telescope. He wanted to create an instrument that would be as ornamental in a garden as it would be utilitarian for terrestrial and celestial observing.



CALTECH

PORTER SKETCHED the exterior of the proposed 200-inch reflector dome at Palomar Observatory. The person just outside the lower doorway and the two people just below the dome's slit are to scale.

CALTECH

PORTER IMAGINED what the interior of Palomar Observatory would look like 10 years before it opened when he made this sketch in 1938. His mechanical designs helped architects visualize the project.

RUSS SCHLEIPMAN

THE PORTER GARDEN TELESCOPE had to be set up only once. After that, it remained outdoors. This picture, from a booklet Russell Porter produced, shows the telescope in use.

◀ **AN ORIGINAL** Porter Garden Telescope is a rare item. Estimates range between seven and 12 surviving units. This beautiful example sold at auction in March 2007.

RUSS SCHLEIPMAN

▲ **RUSSELL W. PORTER,** shown here with an original Porter Garden Telescope set up in an owner's backyard, produced about 50 units. Porter designed the telescope as a 6-inch f/4 Newtonian reflector.

SKINNER'S AUCTION HOUSE

CALTECH

THE MAN BEHIND THE PORTER GARDEN TELESCOPE

Russell Porter was the youngest of five children, and he grew up in Springfield, Vermont. His father was mechanically talented — he built a boat steam engine and established a toy-manufacturing business.

Porter studied engineering, art, and architecture at Norwich University and architecture at Massachusetts Institute of Technology. A restless adventurer, he signed on for Frederick Cook's 1893 exploration cruise along the coast of Greenland. Porter served as an artist and surveyor. He participated in eight northern adventures within 15 years, including a failed North Pole expedition in 1901.

Porter's interest in optics and telescopes came from his work as a surveyor. Also, a hometown friend, machine-tool pioneer James Hartness (who went on to serve as Governor of Vermont) had an interest in astronomy and telescope-building. His friend's interest served as an inspiration for Porter. Hartness also supplied Porter's first mirror blanks, in 1913. Porter wrote articles for *Popular Astronomy* and *Scientific American* about his telescope designs as well as telescope construction.

In 1915, Porter taught architecture at Massachusetts Institute of Technology. Two years later, he went to work for the National Bureau of Standards to develop manufacturing techniques for optical instruments.

RUSSELL W. PORTER (1871–1949) was an adventurer, scientist, surveyor, architect, writer, and artist. He worked on the 200-inch Palomar reflecting telescope as an artist, optical and mechanical designer, and architect.

In 1919, Hartness recruited Porter to work at his machine company as an optical and mechanical engineer. Porter incorporated optics into the machining process.

In August 1920, Porter, with the support of Hartness and another friend, started a club to teach telescope-making. Participants learned how to grind and polish a telescope mirror, as well as eyepiece and mount requirements. Often, salvaged parts were used in the construction of the telescopes. Within a year, participants had built 16 telescopes, and Porter was teaching the new owners how to use them.

From this initial group, the Springfield Telescope Makers formed December 7, 1923. Part of the club's goal was to build an observatory. Porter had inherited some property in an area known as Breezy Hill. Hartness, who was elected governor in 1920, contributed personal funds for an observatory and a clubhouse. Porter came up with the phrase Stellar Fane, which means "a shrine to the stars." He later simplified this to "Stellafane." Since the 1920s, except during World War II, telescope enthusiasts have continued to meet at summer conventions there. — *M. D. R.*

RUSS SCHLEIPMAN

TELESCOPES OF VERMONT'S first prototype demonstrates the new Porter Garden Telescope is a virtual clone of the original.

Porter envisioned the Garden Telescope as a permanent fixture like a sundial, ready for viewing at a moment's notice. A permanent design eliminates setting up and, after observing, dismantling the telescope.

At first glance, the Porter Garden Telescope is so different from other telescopes, it might not be recognized for what it is. The optical-tube assembly has no tube. Porter designed the unit as a 6-inch (152.4 millimeters) f/4 Newtonian reflecting telescope. The eyepieces — 0.983-inch diameter — had focal lengths of 50mm, 25mm, and 12.5mm, giving the observer magnifications of approximately 12x, 24x, and 49x.

The telescope's form is breathtaking. A bowl of bronze lotus leaves supports the mirror. From the side of the lotus bowl, a slender bronze leaf curves upward to support the secondary prism and the eyepiece. Owners describe the design as art nouveau.

Porter bought the prisms and eyepieces from the firm of American telescope-maker John Brashear (1840–1920). Because Porter designed his telescopes to be permanently installed, beautiful protective covers for the optics were standard.

Porter manufactured approximately 50 Garden Telescopes. Records do not indicate how many survive intact. A few museums and science centers have Porter Garden Telescopes on display. A small number also are accounted for in private collections.

Mike D. Reynolds *is a contributing editor of* Astronomy *and Associate Dean of Mathematics & Natural Science at Florida Community College.*

Garden Telescope redux

For years, people talked about a possible rebirth of the Porter Garden Telescope. When examining an original, it becomes obvious it would take special talent and dedication to pull off a reproduction.

A skillfully manufactured replica of the original Garden Telescope is a new project of Telescopes of Vermont, led by Fred Schleipman and his son Russ. The Schleipmans' work on this project has the endorsement of the Springfield Telescope Makers (see "The man behind the Porter Garden Telescope," page 82).

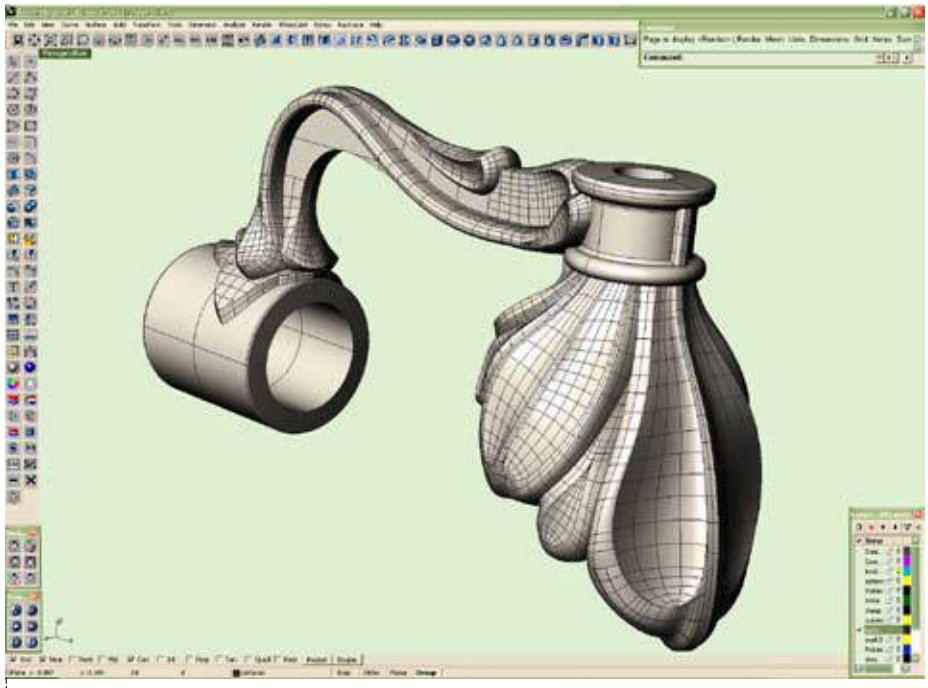
Fred is a skilled machinist. He crafts precision instruments and devices for the most demanding clients. So it is appropriate that he led the way in reproducing the Porter Garden Telescope.

Russ is the pied piper for Telescopes of Vermont. He has attracted attention from not only the astronomy arena, but also from architects and high-end landscapers as they look for unusual and spectacular pieces for their designs.

Designing and constructing the reproductions has been difficult and expensive. The Schleipmans could not locate any blueprints or plans for the original Garden Telescope. So, they considered the optics and the quality Porter would have demanded for the mirrors and the eyepieces.

In addition, working with bronze is not simple because bronze shrinks as it cools. The price of a Schleipman Porter Garden Telescope equals, as it did in Porter's day, the cost of a new car. The original, according to some records cost around $500. Buyers understand this is finely crafted art they are purchasing as well as a piece of history.

The Schleipmans' work on the Porter Garden Telescope has been extraordinary. Just as Russell Porter did nearly a century ago, Schleipman and his team have created a masterpiece. Porter would be pleased that people still admire the beauty of his Garden Telescope and will once again observe our spectacular universe through it.



RUSS SCHLEIPMAN

THE PATTERN MAKER at Telescopes of Vermont had to reproduce each part of the Porter Garden Telescope using design software.

RUSS SCHLEIPMAN

A CLOSER LOOK at the bronze work of the Porter Garden Telescope reproduction by Telescopes of Vermont shows the lotus bowl and the split-ring base. The hourly markings allow the telescope to function as a sundial.

CONTACT INFORMATION

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BRYCE CANYON affords breathtaking views during the day and at night. RAY MATHIS

attendees can participate in workshops about archaeoastronomy and light pollution and walk a scale model of the solar system. Evenings will include stargazing and special presentations about nocturnal animals found in the region. Also, Bryce Canyon National Park offers hiking, camping, and geology lectures.

www.nps.gov/brca/planyourvisit/astronomyprograms.htm.

JUNE 4–20

Astronomy Camp for Teens

Mt. Lemmon Observatory, Coronado National Forest, Arizona. ☎ 520.621.4079; ✉ dmccarthy@as.arizona.edu; www.astronomycamp.org.

JUNE 9–16

Grand Canyon Star Party

North and south rims of the Grand Canyon National Park, 80 miles northwest of Flagstaff, Arizona. ✉ ketelsen@as.arizona.edu or margewms@mindspring.com; www.tucsonastronomy.org/gcsp.html.

JUNE 12–17

Heart of America Star Party

Marais des Cygnes Wildlife Area, Butler, Missouri. ✉ dj102356@hotmail.com; www.hoasp.com.

JUNE 14–17

Rocky Mountain Star Stare

Pike National Forest, near Colorado

Springs, Colorado. ✉ chairman@rmss.org; 💻 www.rmss.org.

JUNE 14–17
Wisconsin Observers Weekend
Hartman Creek State Park, Waupaca, Wisconsin. 💻 www.new-star.org.

JUNE 15–16
Apollo Rendezvous
The Boonshaft Museum of Discovery and John Bryan State Park, Dayton, Ohio. ☎ 937.236.4090; 💻 www.mvas.org.

JUNE 15–16
Colorado West Star Party
Uncompahgre Plateau, about 40 miles southwest of Grand Junction, Colorado. 💻 www.wcacastronomy.org/SP07.html.

JUNE 15–16
Craters of the Moon Star Party
Craters of the Moon, near Arco, Idaho. ☎ Mike Hart at 208.528.7672; ✉ mike@comdesigns.com.

JUNE 15–17
Pie in the Sky Star Festival
Pie Town, New Mexico. ✉ camphanrahan@gilanet.com.

JUNE 23–25
North Dakota Star Party
Cross Ranch State Park, Center, North Dakota. 💻 www.und.edu/org/nsas.

JUNE 28–JULY 1
Astronomy Roundup
University of Calgary, Calgary, Alberta. The Royal Astronomical Society of Canada will hold its general assembly in conjunction with the AAVSO's spring meeting and ALPO's annual meeting. ✉ AR2007@shaw.ca; 💻 www.calgary.rasc.ca/ar2007.

CONTACT INFORMATION

Please submit club announcements 5 months in advance to Coming Events, *Astronomy*, P. O. Box 1612, Waukesha, WI 53187, or kneubauer@astronomy.com. Also use this e-mail address to submit your events for our online calendar.

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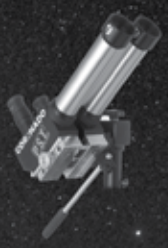

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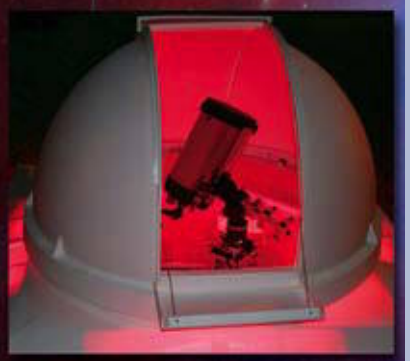

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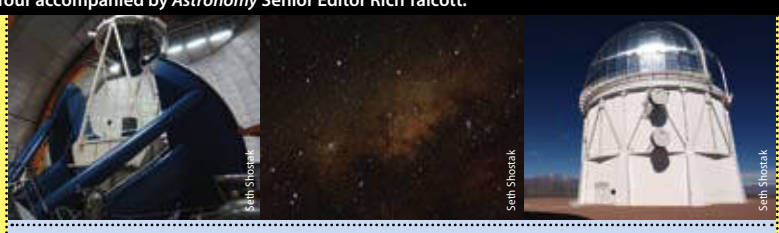

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Reader gallery

EMISSION NEBULA IC 1848 (5-inch Tele Vue NP127is apochromatic refractor at f/5.2, SBIG STL-11000M CCD camera, HαRGB image with sixteen 8-minute exposures through an Hα filter, and eight 8-minute exposures through red, green, and blue filters) /// **JIM BURNELL, WARWICK, NEW YORK**

THE SOUL OF THE NIGHT

A baby rests in Cassiopeia

This "combination" deep-sky object lies in a vast star-forming region in Cassiopeia. Nebulosity surrounds the stars and, together, they form IC 1848. The label is a bit confusing because it refers to both the faint nebula and the open star cluster within. The nebula's hydrogen atoms absorb ultraviolet light from the stars and reemit it as visible light with a reddish hue. Observers often call this object the Baby Nebula or the Soul Nebula. The latter refers to IC 1848's nearness to a similar object, the Heart Nebula (IC 1805). IC 1848 lies 2° north of the Perseus border and 5° north-northeast of the Double Cluster (NGC 869 and NGC 884).

GLOBULAR CLUSTER M30 in Capricornus lies about 3° east-southeast of magnitude 3.7 Zeta (ζ) Capricorni. M30 lies 26,000 light-years away and shines at magnitude 7.2. (14.5-inch RC Optical Systems Ritchey-Chrétien reflector at f/9, SBIG STL-11000 CCD camera, LRGB image with exposures of 50, 25, 25, and 25 minutes, respectively) /// **DANIEL VERSCHATSE, ANTILHUE OBSERVATORY, CHILE**

GLOBULAR CLUSTER M55 in Sagittarius is the brightest of the four globulars shown here, at magnitude 6.3. Find it 8° east-southeast of magnitude 2.6 Zeta (ζ) Sagittarii. (14.5-inch RC Optical Systems Ritchey-Chrétien reflector at f/9, SBIG STL-11000 CCD camera, LRGB image with exposures of 45, 20, 20, and 20 minutes, respectively) /// **DANIEL VERSCHATSE, ANTILHUE OBSERVATORY, CHILE**

GLOBULAR CLUSTER M68 in Hydra glows at magnitude 7.8 and appears 11' in diameter. To find it, draw a line from Delta (δ) to Beta (β) Corvi, and extend the line an additional 3.5°. (14.5-inch RC Optical Systems Ritchey-Chrétien reflector at f/9, SBIG STL-11000 CCD camera, LRGB image with exposures of 60, 16, 16, and 16 minutes, respectively) /// **DANIEL VERSCHATSE, ANTILHUE OBSERVATORY, CHILE**

GLOBULAR CLUSTER M72 in Aquarius lies about 3.5° south-southeast of magnitude 3.8 Epsilon (ε) Aquarii. At magnitude 9.3, M72 is one of Messier's faintest globulars. (14.5-inch RC Optical Systems Ritchey-Chrétien reflector at f/9, SBIG STL-11000 CCD camera, LRGB image with exposures of 50, 20, 20, and 20 minutes, respectively) /// **DANIEL VERSCHATSE, ANTILHUE OBSERVATORY, CHILE**

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Please include your full name, date and location of image, and complete photo data: telescope, camera, film, and exposure information.

COMET McNAUGHT shone brightly over Argentina's Patagonia region, near latitude 41°03' south and longitude 71°09' west. Even in twilight and against city lights, the comet's tail showed a lot of structure. (Canon EOS Rebel XT, lens set at 54mm and f/5.6, 13-second exposure, taken January 18, 2007, at 10:43 P.M. local time) /// **MARTÍN MOLINÉ, SAN CARLOS DE BARILOCHE, ARGENTINA**

McNAUGHT FROM URUGUAY impressed everyone who saw it. The imager captured the comet from an outdoor cafe at Punta del Este Harbor. The coastline was filled with people carrying binoculars and cameras. (Canon S3-IS digital SLR, lens set at 37.5mm and f/3.5, 0.5-second exposure, taken January 17, 2007, at 9:39 P.M. local time) /// **GUILLERMO MILLAN, OCEANSIDE, NEW YORK**

McNAUGHT'S TAIL stretched some 45° from its nucleus in this picture from Chile. The imager sought out a hilltop at 5,118 feet (1,560 meters) elevation with a perfect view of the western horizon. The city lights come from Santiago on the left and Valparaiso on the right. Naked-eye observers could trace the tail for 30°. (Canon 5D digital SLR, lens set at 45mm and f/2.8, ISO 1600, 30-second tripod-mounted exposure, taken January 21, 2007, at 10:29 P.M. local time) /// **RICHARD SIMON, SANTIAGO, CHILE**

VAN DEN BERGH 14 AND 15 are a dazzling mixture of emission (red) and reflection (blue) nebulosities. They lie in the far-northern constellation Camelopardalis the Giraffe, only 4° east of IC 1848 (see page 85). (7.1-inch Takahashi 180 Astrograph, Apogee U9 CCD camera, HαRGB image with exposures of 7.75, 3, 3.5, and 3.25 hours, respectively) /// **ADAM BLOCK AND TIM PUCKETT, ELLIJAY, ARIZONA**

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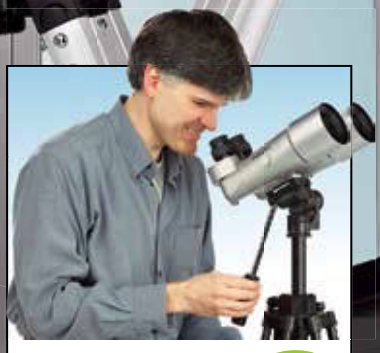

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